Draft

DRAFT ENVIRONMENTAL STATEMENT

OPERATION OF THE DELTA PUMPING PLANT;

BY

U. S. ARMY ENGINEER DISTRICT
SACRAMENTO, CALIFORNIA

Sacramento-San Joaquin delta
Water resources development--Ca
Water quality management--Ca--
Sacramento-San Joaquin delta

no sh

DECEMBER 1978

SUMMARY

(X) Draft ( ) Final Environmental Statement

Responsible Office: U.S. Army Engineer District
Sacramento, California

1. Type of Action: (X) Administrative ( ) Legislative

2. Brief Description of Action: The California Department of Water Resources (DWR) has applied for Department of Army permits for the existence and operation of the Delta Pumping Plant, Intake Channel, Clifton Court Forebay, and appurtenant facilities. These facilities, part of the State Water Project (SWP), divert water from the Sacramento-San Joaquin Delta for conveyance via the California and South Bay Aqueducts to service areas in the South San Francisco Bay, San Joaquin Valley, and Southern California. Deliveries to the Central Coastal Area are planned.

The Pumping Plant was designed for 11 pumps; presently 7 pumps are installed with a capability of 6,300 cfs. A fish protective facility is constructed near the beginning of the Intake Channel. Operation of the Pumping Plant and Forebay is coordinated with other facilities of the SWP and the federal Central Valley Project (CVP) to meet applicable Federal and State water quality standards for the Delta and Suisun Marsh.

Modified standards were established in August 1978 which incorporate the latest knowledge on protection of beneficial uses and mitigative measures for CVP and SWP operation. The latest water rights decision requires expansion of ongoing ecological studies of the Delta and the Bay. To satisfy court order, this statement covers the operation of existing Delta Pumping Plant. Applications for a Department of the Army permit for installation and operation of four additional pumps will be covered later in a supplement to this statement.

3. Summary of Environmental Impacts and Adverse Environmental Effects

a. Project operations affect natural tidal fluctuations and lower nearby water levels, but the drawdowns do not affect any known use of local channels.

b. Project operations provide good quality water to 24 contracting agencies, which encompass about 18 percent of the State's land area and contain about 63 percent of its assessed valuation and 66 percent of its population. SWP supplies help stabilize ground water levels, protect ground water quality, and save users millions of dollars annually in water quality costs. Agricultural uses of project water in the San Joaquin Valley generate at least 11,000 jobs and contribute at least $245 million annually to the State's economy.

c. Project operations also support substantial use of recreation facilities along the Aqueduct system(3.1 million recreation-days in 1975). An undetermined but significant part of this use is due to incidental export of small fish.

d. Pumping Plant operations are constrained by the availability and cost of on-peak energy for the entire aqueduct system, and therefore involve maximum use of off-peak energy, which can be obtained by using existing utility generating capacity. System energy requirements are related to the quantities of water delivered. Energy requirements for full usage of the existing Delta Pumping Plant amount to about 0.5 percent of statewide requirements in 1980.

e. Pumping Plant operations contribute to the overall decrease of outflow from the Delta that is caused by numerous federal, State, and local water projects. These reduced flows, and the increased salinity intrusion which accompanies them, reduce populations of fish and other aquatic organisms and degrade habitat for waterfowl in Suisun Marsh.

f. Under present conditions, CVP and SWP pumping modifies flows significantly in many Delta channels. In addition to compounding operational problems, the flow modifications adversely affect fish, chiefly through flow reversals in some channels and increased velocities in others. The flow organisms to the pumps, and probably delay and confuse upstream migrant fish. The increased velocities reduce the abundance of many invertebrates which fish feed on.

g. Generally, project effects are most severe in critically dry years and least in wet years. Some major effects are: (1) reduced survival of young striped bass by an average of 23 percent; (2) reduced Neomysis abundance by 12 to 81 percent; (3) a 14 percent reduction of waterfowl food supplies in the Suisun Marsh during a critically dry year, after allowing for scheduled initial facilities to provide early protection for the more vulnerable areas.

h. Long-term salinity increases in tidal waters adjacent to Suisun Marsh, partially attributable to SWP pumping, are expected to gradually cause vegetative changes in the intertidal marshes, which may increase costs for Marsh management and levee maintenance, and reduce the range and density of aquatic mammals and some birds. Habitat for certain rare and endangered species would be improved.

i The SWP diversions remove an estimated 10 percent of annual inflows of suspended sediment to the Delta.

j Under present conditions, SWP deliveries contribute slightly to the salt balance and drainage problems in the Tulare Lake Basin in the southern part of the San Joaquin Valley.

4. Alternatives Considered

a. Moderate reduction of pumping.

b. Severe reduction of pumping.

c. Cease pumping.

d. Continue with present pumping capacity to meet the State's contractual obligation.

Also, expanded operation with four additional pumps and an enlarged fish facility is discussed.

5. Comments have been requested from:

US Senator - Honorable Alan Cranston
US Senator - Honorable S. I. Hayakawa
US Representative - Robert L. Leggett
US Representative - George Miller
Advisory Council on Historic Preservation
Council on Environmental Quality
US Department of Agriculture
US Department of Commerce
US Department of Health, Education, and Welfare
US Department of Housing and Urban Development
US Department of Interior
US Department of Transportation (Federal Highway Administration)
Commander, Twelfth Coast Guard District
Environmental Protection Agency
Federal Energy Commission
Federal Power Commission
State Senator - Honorable John F. Dunlap
State of California, State Clearinghouse
San Joaquin Valley Interagency Drainage Program
Alameda County Flood Control & Water Conservation District
Antelope Valley - East Kern Water Agency
Castaic Lake Water Agency
Dudley Ridge Water District
Hacienda Water District
Mojave Water Agency
Alameda County Water District
Crestline - Lake Arrowhead
Coachella Valley County Water District
Desert Water Agency
Kern County Water Agency

The Metropolitan Water District of Southern California
Devils Den Water District
Empire West Side Irrigation District
Little Rock Creek Irrigation District
Oak Flat Water District
Palmdale Water District
San Gorgonio Pass Water Agency
Ventura County Flood Control District
San Bernardino Valley Metropolitan Water District
San Luis Obispo County Flood Control & Water Conservation District
San Gabriel Valley Metropolitan Water District
Wheeler Ridge - Maricopa Water Storage District
Santa Clara Valley Water District
Santa Barbara County Flood Control & Water Conservation District
Tulare Lake Basin Water Storage District
Contra Costa County Water Agency
South Delta Water Agency
Contra Costa County Water District
Kings County Regional Planning
Central Delta Water Agency
San Diego County Water Authority
Water Resources Center, U.C. Davis
Association of State Water Project Agencies
Department of Water Science & Engineering, U.C. Davis
California Committee of Two Million
Planning & Conservation League
League of Women Voters
Association of Bay Area Governments
Bethel Island Municipal Improvement District
California Advisory Commission on Marine and Coastal Resources
California Pilots Association
California Trout
California Waterfowl Association
California Wildlife Federation
Contra Costa Park Council
Environmental Defense Fund
Friends of the River
Friends of the Earth
Golden Gate Chapter, Audubon Society
National Audubon Society
National Wildlife Federation
Pacific Interclub Yacht Association
San Francisco Bay Marine Reserve Center
Northern California Committee for Environmental Information
Oceanic Society
San Francisco Bay Conservation and Development Commission
Save San Francisco Bay Association
Sierra Club
Suisun Resource Conservation District
People for Open Space

The Nature Conservancy
West Contra Costa Conservation League
Marine Exchange of San Francisco
11 Individuals

6. Draft Statement to EPA ______________________________.

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Introduction.

1.00 In 1971, the Sierra Club, Friends of the Earth, and others filed suit in Federal District Court (Sierra Club v. Morton) alleging unlawful construction and operation of the Delta Pumping Plant of the State Water Project (SWP) and the U.S. Bureau of Reclamation's Tracy Pumping Plant of the Federal Central Valley Project (CVP). Failure to comply with the Rivers and Harbors Act of 1899, which requires permits for projects in or affecting navigable waters, and the lack of environmental documents pursuant to the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA), were the primary bases of the suit.

1.01 The Court ruled in 1975 that diversions of water through both pumping plants require Corps of Engineers' permits. The ruling also requires the Corps to comply with requirements of NEPA prior to the issuance of these permits. This case has been appealed by the Department of Water Resources (DWR) and the Bureau of Reclamation (USBR). DWR submitted a permit application to the Corps of Engineers for the operation of the Delta Pumping Plant pursuant to Section 10 of the Rivers and Harbors Act, but has reserved the right to withdraw the application if it is successful in its appeal of the Sierra Club V. Morton Case. This application is for a permit for the continues existence and operation of the existing plant. A second application has been made for a permit to install and operate four additional pumps in the Delta pumping plant. Second application for the four additional pumps will be addressed separately at a later date and will be evaluated in a supplement to this Environmental Statement.

The Existing Project.

1.02 The Delta Pumping Plant is located at the head of the California Aqueduct approximately 19 kilometers (12 miles) northwest of Tracy, California, near the Contra Costa-Alameda County line. As shown in Figure 1, this plant provides the initial lift and starts the water flowing south in the California Aquedect of the SWP for irrigation, municipal and industrial, and other uses in the San Joaquin Valley, South San Francisco Bay Area, and Southern California. Project water flows through the Sacramento-San Joaquin Delta channels to the Clifton Court Forebay. It then flows through control gates into the forebay and then into an open canal (intake channel) to the pumping plant. The Delta Fish Protective Facility is located on this Intake Channel which connects the forebay to the pumps. From the plant, water flows into Bethany Reservoir, there water for the South Bay Aqueduct is diverted. The major portion of the flow continues south in the California Aqueduct towards the other service areas. This water is entirely contracted for by local agencies.

1.05 The existing facilities of the SWP covered under this report are Clifton Court Forebay, the Intake Channel, the Delta Fish Protective Facility, and the Delta Pumping Plant, with a capacity of 6,300 cfs. (See Figure 1). These facilities, together with the nearby Delta Operations and Maintenance Center, are hereinafter called the "Delta Complex".

Planning and Construction of Delta Complex.

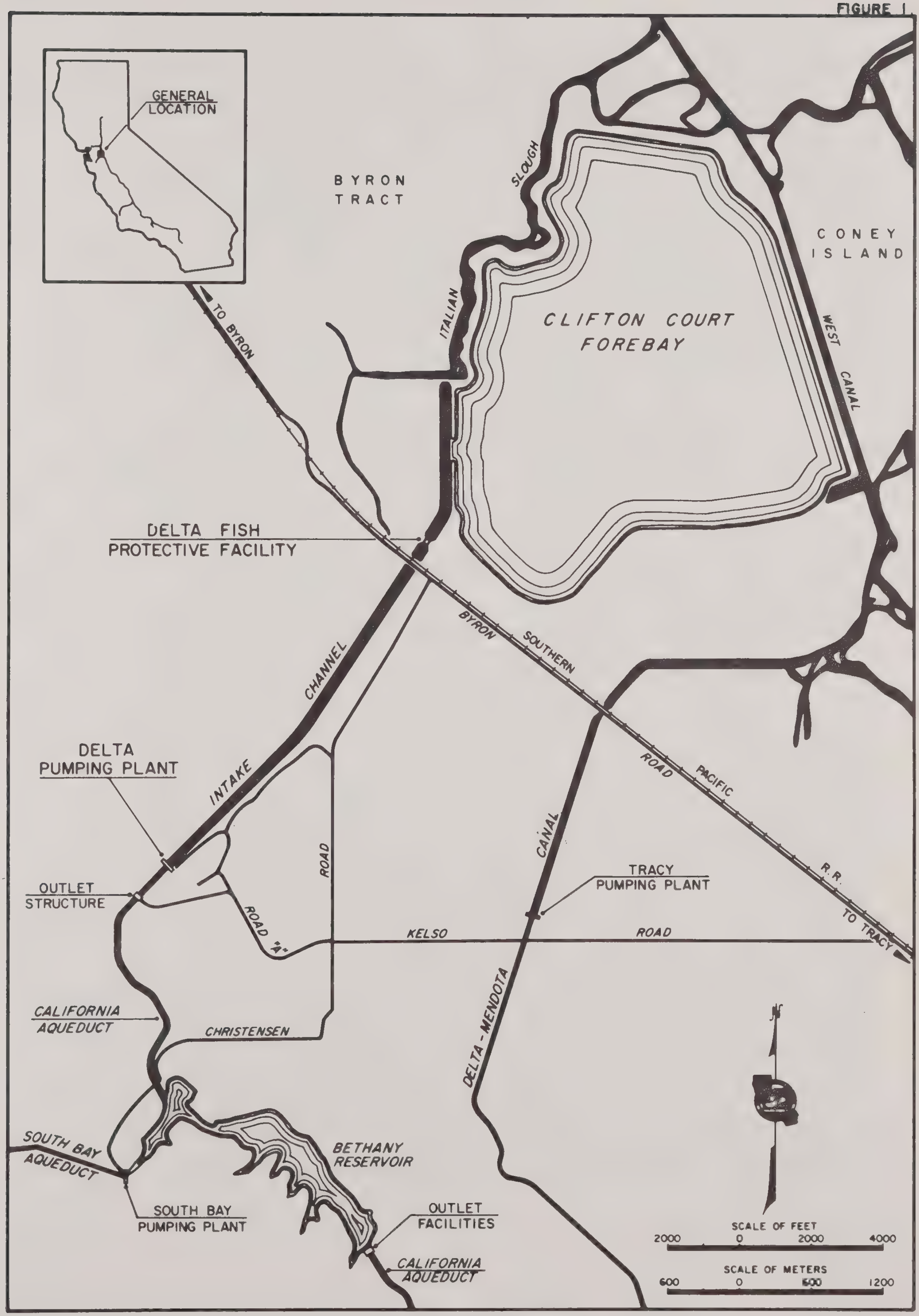
1.04 In the earliest studies of plans for conveying water from the surplus water areas in the north to areas of deficient supply in the Bay Area, San Joaquin Valley, and Southern California, it was apparent that the logical and most practicable plan would be to use the Sacramento-San Joaquin Delta as the point of diversion.

1.05 Italian Slough, an inlet off the Old River Channel of the San Joaquin River, was first proposed as a point of diversion in a 1951 feasibility report of the State Water Resources Board (34)*. Italian Slough was then a leveed and maintained channel which most closely approached an aqueduct routing for conveyance of water to the South Bay area and along the west side of the San Joaquin Valley. The 1951 report proposed construction of a mile-long intake canal leading to a pumping plant. Until about 1966, when planning began for Clifton Court Forebay, this basic concept of Italian Slough-Intake Canal-Pumping Plant-Aqueduct was incorporated into all subsequent planning for what was to become the State Water Project. Italian Slough was named as the point of diversion in the State's water right applications.

1.06 Planning studies necessary for final design of the intake canal and the Delta Pumping Plant began early in 1961, soon after voter approval of the Burns-Porter Act. Such studies were made to define the siting and alignment of the Pumping Plant, and the number and capacities of the pumping units. The plant location and intake channel termination were determined by comparing the cost of deep channel excavation with the cost of pump discharge lines plus excavation and backfill. The resulting depth of cut at the plant was approximately 49 meters (160 feet).

1.07 The Burns-Porter Act established the capacity of the north end of the California Aqueduct at not less than 10,000 cfs (State Water Code Section 12934). This capacity, together with 300 cfs capacity for the South Bay Aqueduct, determined the ultimate capacity of the Delta Pumping Plant at 10,300 cfs. The decision that the plant would ultimately contain 9 units at 1,067 cfs and 2 units at 350 cfs was based on projected ultimate demands, flexibility of operation in conjunction with the California and South Bay Aqueducts, and

*Numbers in parenthesis designate references listed numerically in the Bibliography.



LOCATION MAP

accommodation of off-peak operation. The decision for initial installation of 7 units with a total capacity of 6,300 cfs was based on maximization of off-peak operation during the initial years and the policy not to build facilities before they were needed.

1.08 Construction of the intake channel began in August 1963 and was completed in February 1967. Construction of the intake channel involved relocation, temporary detours, or canal crossings for the following facilities: Burns Road, Byron Road Bridge, Southern Pacific Railroad Bridge, Clifton Court Road Bridge, irrigation facilities and two oil and gas pipelines. Total excavation amounted to about 14.5 million cubic yards, including rough excavation for the pumping plant. Excavated material was either placed in designated spoil areas or used in embankments. Horizontal drains were installed in the excavated cut slopes to reduce possible slides.

1.09 In 1955 the USBR had constructed the Tracy Fish Collecting facility at the intake to the Delta-Mendota Canal. The need for a similar facility at the intake of the California Aqueduct was apparent in the earliest stages of planning. Investigations to determine the location and type of facility began in 1962. As a result of these investigations, the louver concept was adopted as the most practicable salvage method available at the time. Construction of the fish protective facility began in May 1966 and was completed in January 1970. However, operation of completed portions of the facility began in 1968. Material excavated was used for embankment of the intake channel. Besides dewatering, excavation, backfill, and construction of concrete channels, the work included installation of louvers, pumps, gantry, net frame, and testing equipment.

1.10 As previously mentioned, the initial excavation for the Delta Pumping Plant was done concurrently with the intake channel excavation. The major work on the plant started in August 1964 and was completed in February 1969. The pumping plant bowl was further excavated under the pump units. Additional excavation was performed for the discharge lines and the outlet structure. The major portion of the concrete required for plant construction was provided from a nearby batch plant. Several contracts were awarded to furnish and install the electrical and mechanical equipment.

1.11 It was recognized that the water demands of the California Aqueduct would exceed the capacity of Italian Slough by about 1969. A solution to this problem was the proposed Clifton Court Forebay, which would serve several purposes: eliminate the need for increasing the capacity of the existing channels, provide forebay storage for the Pumping Plant and increased use of off-peak power, permit diversions from the Delta during favorable tides, and avoid diversions during unfavorable tides. Clifton Court Forebay required the acquisition of 1,068 hectares (2,639 acres) of land from 11 property owners. The initial program included an additional 400 hectares (1,000 acres) of

recreation lands located on the north and west boundaries of the reservoir. However, landowner opposition to the recreation proposal resulted in abandonment of this recreation plan. The remaining land acquisition program was one of some difficulty due to the reluctance of affected landowners to sell. As a result, a condemnation action was filed and orders for possession were served on the property owners to meet scheduled construction, but prior to award of contract, the property owners filed an injunction to set aside the order for possession. This resulted in a hearing and a decision favorable to the State, and all parcels were acquired through negotiated settlements. Land acquisition for the forebay began in 1967 and was completed in 1968.

1.12 Construction of Clifton Court Forebay began in December 1967 and was completed in December 1969. The work included dewatering and drainage, reservoir clearing, excavation, embankment construction, concrete work, and mechanical and electrical installations for the control structure. Reservoir clearing consisted of removing all trees, stumps, brush, culverts, tanks, fences, buildings, privies, cesspools, leaching lines, discarded equipment and debris. Excavation from the forebay provided material used in the embankments.

1.13 When the forebay became operational in November 1969, the end of the Italian Slough Intake Channel was closed, and the remainder of the Intake Channel was connected to the forebay. Thus, the place of diversions from the Delta was switched from Italian Slough to the intake structure connecting the forebay to West Canal.

DWR Bulletin No. 200 (24) documents the planning, financing, design, right-of-way acquisition, and construction of the Delta Complex and other SWP facilities.

Operation of the Delta Complex.

1.14 The Delta Pumping Plant lifts water 74.4 meters (244 feet) from the intake channel to the California Aqueduct. Exterior and interior photographs are shown on Figures 2. The plant consists of a substructure of reinforced concrete and a superstructure of structural steel with precast concrete wall panels and a composition roof. Overall plant dimensions are 153.6 meters (504 feet) long, 29.9 meters (98 feet) wide, and 33.2 meters (109 feet) high. The plant has an indoor bridge crane for assembly and maintenance of major equipment. The plant structure has four floor levels.

1.15 The pumps are all vertical shaft, single-stage, centrifugal units. Seven pump units are presently installed: two 9.9 m3/s (350 cfs) units (Units 1 and 2) driven by 8,392 kilowatt (11,200 horsepower) electric motors, and five 30.2 m3/s (1,067 cfs*) units

*Rated installed capacity is 6,035 cfs; 6,300 cfs has been achieved.

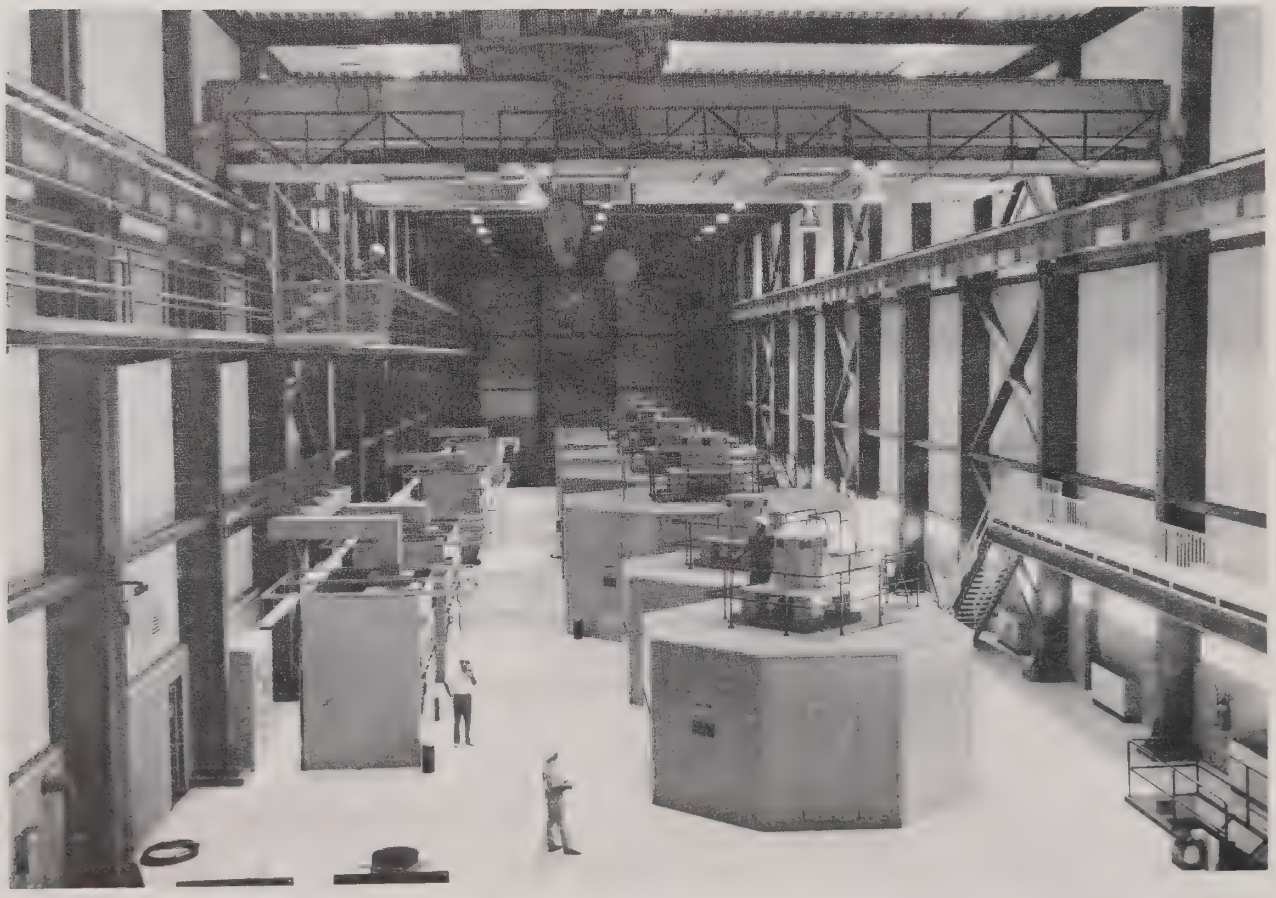


Figure 2. Delta Pumping Plant

(Units 3 through 7) driven by 25,737 kilowatt (34,500 hp) motors. The space reserved for the four additional units presently consists of subfloors, pits, and intake structures, at the northwestern end of the plant. A plan of the Delta Pumping Plant is shown in Figure 3.

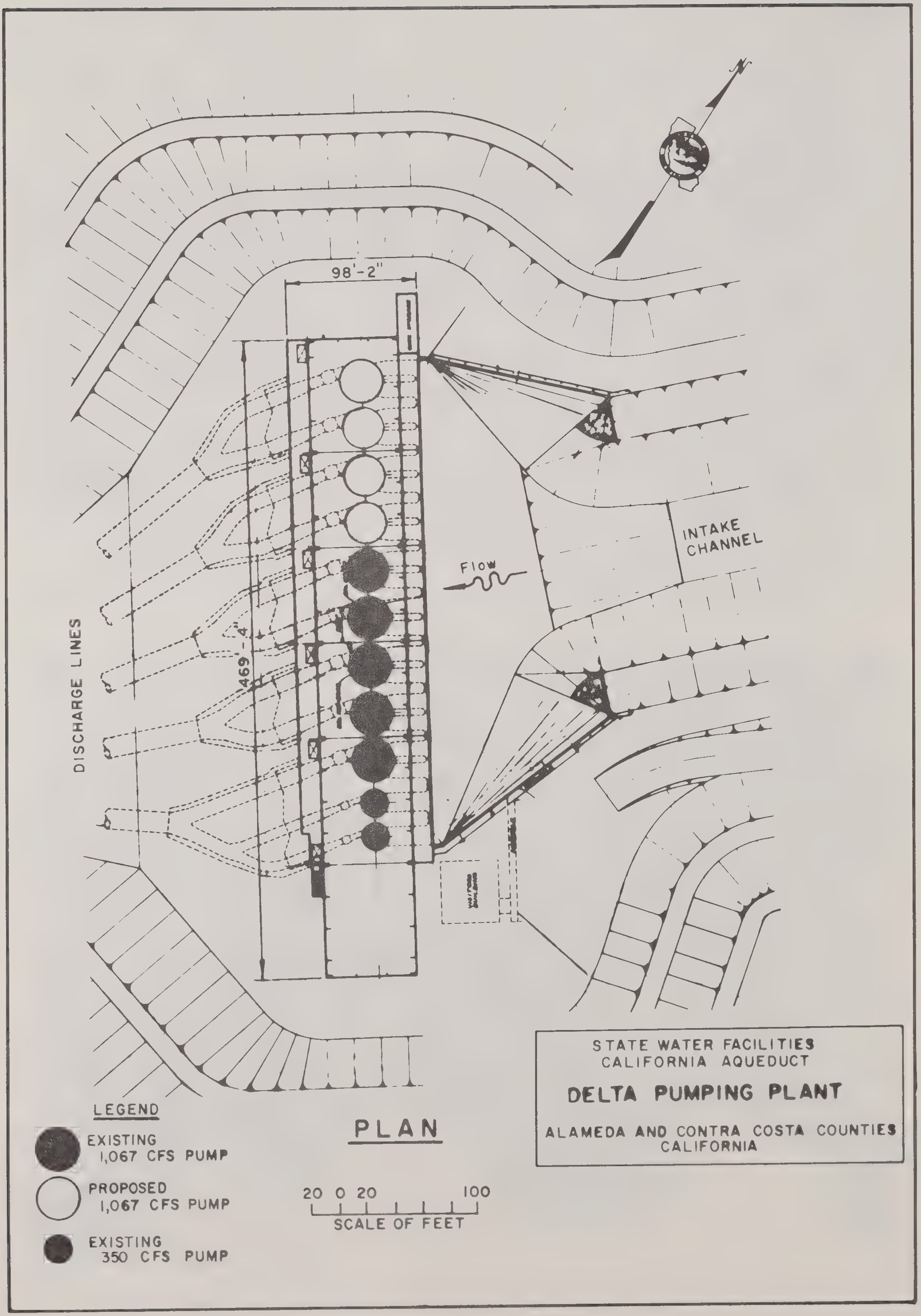
1.16 The pumps lift water into the California Aqueduct through three of the five existing discharge lines, as shown in Figure 3. These buried lines converge towards the junction with the outlet transition structure. The reinforced-concrete outlet structure consists of five bays and an outlet transition to the trapezoidal concrete-lined aqueduct. A radial- gated outlet structure prevents water in the aqueduct from flowing back into the discharge lines during emergencies or inspection and maintenance.

1.17 The plant's electrical installation includes a 230-KV switchyard, power transformers, motors, switchgear, and auxiliary systems.

1.18 The Delta Operations and Maintenance Center is located adjacent to the Delta Pumping Plant. This complex of six one-story buildings is the headquarters of the Delta Field Division, which is currently responsible for the South Bay Aqueduct and the California Aqueduct north of the Federal-State joint-use facilities near Los Banos. Employees headquartered at the Center, presently numbering 104, perform the functions of administration, engineering, plant maintenance, civil maintenance, and water operations.

1.19 From the discharge lines of the Delta Pumping Plant, the aqueduct conveys water about 2.1 kilometers to Bethany Reservoir, which is bounded by natural terrain and several small earth dams. The South Bay Pumping Plant is located on the western shoreline.

1.20 DWR's Project Operations Control Center (POCC) in Sacramento is responsible for the management and coordination of the entire SWP system. The SWP is divided into five separate control areas: Oroville-Thermalito, Delta, San Luis, San Joaquin, and Southern California. Each area has a center from which all facilities within that area are remotely controlled. The control system consists of instrumentation, communications, computers, and other electronic equipment to provide for the remote monitoring and control of all facilities. POCC continually monitors the operation of all project facilities and also serves as a back-up control center. The POCC prepares annual and monthly plans of operation based on contractor entitlements and surplus requests, hydrologic forecasts, reservoir storage and system capabilities. With a computer it also prepares monthly, weekly, and daily water and power schedules, which are transmitted to the area control centers. The POCC continuously coordinates the schedules with the Bureau of Reclamation, power suppliers and users, and other affected agencies.



STATE WATER FACILITIES
CALIFORNIA AQUEDUCT

DELTA PUMPING PLANT

ALAMEDA AND CONTRA COSTA COUNTIES
CALIFORNIA

1.21 For the Delta Complex, the daily schedules call for prescribed amounts of water to be pumped off-peak and on-peak and to be diverted into Clifton Court Forebay. The amounts to be pumped and diverted vary greatly from day to day, since they represent optimization of system capabilities under the operational constraints and constantly changing conditions in the Delta and elsewhere.

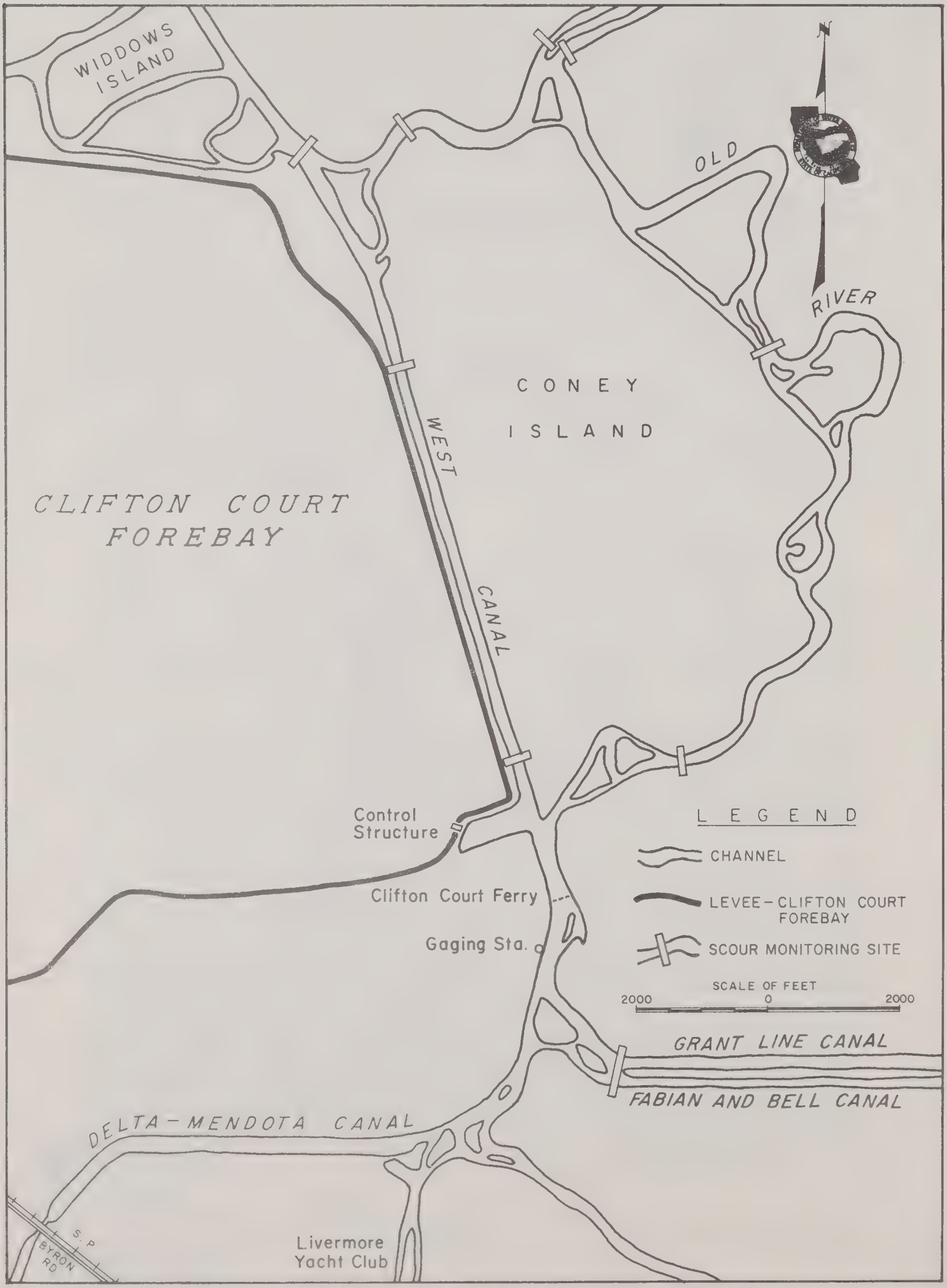
1.22 Basically, there are two operating conditions with respect to Delta flows; surplus flows and balanced flows.

a. Surplus Flow Conditions: During normal and above normal runoff periods, the capability of the aqueduct system to convey and store Delta diversions usually governs operations. The capacities of all the pumping plants, coupled with the availability of on-peak power is an important factor. Another is the limitation on water surface fluctuation in the aqueduct under the "controlled volume operation". This operation entails increases or decreases in aqueduct flows (by starting and stopping pumping units and raising or lowering check gates) without appreciably changing the volume of water in the canal cross section. Minimizing water level fluctuation reduces the risk of failure of the canal lining.

b. Balanced Flow Conditions: During low runoff periods and/or critical fish periods, the needs of the Delta are the controlling factors. The operational schedules are then basically an allocation of Delta supplies available for CVP and SWP export, after allowance for Delta inflows (as affected by system reservoir releases), Delta internal uses, and Delta outflows required for meeting the water quality criteria.

Clifton Court Forebay accommodates mismatches between the rate of inflow from the Delta, which is governed by tides, and the draft of the Delta Pumping Plant, which makes maximum use of off-peak power for pumping by drawing on the forebay water storage. This operation avoids diverting from Delta waters during low tides.

1.23 At maximum water surface elevation of 1.52 meters (5 feet) above mean sea level (USGS datum), the forebay has a surface area of 853 hectares (2,109 acres), a shoreline length of 12.9 kilometers (7.74 miles) and a storage capacity of 35.3 cubic hectometers (28,653 acre-feet). The inlet is at the southeast corner of the forebay and taps the Delta at the southern junction of West Canal and Old River. The Delta channels near the intake structure are shown in Figure 4. Diversions through the inlet are controlled by five 6.1-meter-wide (20-foot) by 7.77-meter high (25.5 foot) radial gates which are opened during high tides and closed during low tides. Water is withdrawn from the forebay into the pumping plant intake channel through an outlet on the west side of the forebay. This outlet is uncontrolled



DELTA CHANNELS NEAR CLIFTON COURT INTAKE

and the flow rate is regulated by the pumping rates. Except for the inlet and outlet, the forebay is bounded by levees.

1.24 Tidal fluctuations are a major factor in the operation of Clifton Court Forebay. By intentional design, water can be diverted into the forebay only when the tide elevation outside is higher than the water level within. Under normal flow conditions, the forebay storage is usually maintained at a relatively high level and the intake gates are opened when there is a head differential of at least 0.15 meters (0.5 feet). Under drought conditions, the forebay storage is maintained at a lower level to provide greater flexibility in diversions under daily and hourly variations in tides and water availability.

1.25 Other operating procedures for the Forebay are:

a. Opening of the intake gates is limited so that mean water velocities in the nearby channels do not exceed 0.9 meters per second (3 feet per second). Such velocities are considered nonscouring. The velocities are monitored while the gates are opened.

b. The gates are closed for at least 1.5 hours before and after lowtides to minimize the effects on nearby water levels. The forebay and the Delta and Tracy Pumping Plants have the operational capability to respond quickly to changing conditions in the Delta. This capability was demonstrated during the draught and following the Andrus Island levee break in 1972. Varying the releases from CU Pond SWP reservoirs takes longer to be effective in the Delta - one day for Folsom Lake, two days for Lake Oroville, and five days for Shasta Lake.

The 4.67-kilometer-long (2.9 mile) canal connecting Clifton Court Forebay to the Delta Pumping Plant has rock slope protection. It is designed to convey 10,300 cubic feet per second at a flow depth of 11.6 to 12.8 meters (38 to 42 feet). For safety reasons, sport fishing and waterfowl hunting are prohibited in the channel.

1.26 The Delta Fish Protective Facility, located on the intake channel adjacent to Clifton Court Forebay, salvages fish before they are drawn into the California Aqueduct by the pumping plant. The fish are collected from the water flowing toward the Delta Pumping Plant, placed into tank trucks, and delivered back to Delta waters at locations outside the influence of the export pumps. The facility was designed to salvage a majority of four main species of fish: king salmon, striped bass, white catfish, and American shad. It is not feasible to collect eggs of fish or larvae smaller than one inch in length at the facility. Very few large fish are taken, because they cannot pass through the trashrack (2-inch opening between bars) and are strong enough to turn around and swim against the current.

1.27 The facility, shown in Figure 5, is a large structure consisting of primary and secondary louver systems and collection and holding tanks. Successful operation depends on the ability of fish to sense and avoid an obstruction in their path as they drift downstream with the current. The obstruction consists of the system of louvers across the intake channel. The louvers, placed at an angle of 15° to the center line of the channel, divert the fish into bypass pipes which lead to a smaller secondary channel and louver system. The secondary louver system in turn diverts the fish into four adjacent holding tanks. Most of the flow in the intake channel passes through the primary louvers to the Delta Pumping Plant.

1.28 At this facility, the intake channel converges into a rectangular, reinforced concrete channel section, divided into seven channels by piers. Control gates are provided to maintain velocity control. Downstream of the control gates, the channel is divided into four bays; two are in operation and two have no louvers. At the present time, channels 5, 6, and 7 have no control gates and are not operating. These channels will be operated together when the capacity of the Delta Pumping Plant is increased.

1.29 DWR has monitored water quality at the Delta Pumping Plant since pumping operations began. Water quality measurements were also started at selected stations along the California Aqueduct as it was extended south- ward. This monitoring is to assure that the water quality objectives for delivery of export water are met.

1.30 Since exports began, DWR has also monitored water quality in the Delta for compliance with applicable State and Federal standards. The scope of Delta water quality monitoring has greatly expanded over the years for compliance with the applicable standards. The monitoring sites, the parameters, and the sampling frequency vary somewhat from year to year. They are shown in the annual reports on the Interagency Ecological Study Program. The SWP by recent Decision (D-1485) specifies a detailed monitoring program, including special studies needed to help address major concerns that cannot be resolved now due to lack of data.

In 1969, DWR initiated a monitoring program to detect possible scour and deposition in the Southern Delta channels near the Tracy and Delta Pumping Plants. This program has documented changes in cross-sectional areas without attempting to identify or quantify the causes. There are now 30 monitoring sites under continuous surveillance, and additional sites are now being installed. Analysis of data collected between the initial measurements and 1976 reveals that channel depths at most sites have changed only slightly (32).

Figure 5. Fish Protective Facility

Related Water Development Projects.

1.31 The Delta Pumping plant is not an isolated project, but rather one of many integral facilities of the SWP. In turn, the SWP must be considered in the context of water development in California, particularly the Federal CVP, and the needs of the Sacramento-San Joaquin Delta.

1.32 Water transfer systems are the dominant characteristics of the water scene in California. The metropolitan areas of Southern California and San Francisco Bay, after developing nearby water supplies, have had to develop additional supplies from distant areas. The City of Los Angeles built the Owens Valley Aqueduct from the east side of the Sierra Nevada, and the Metropolitan Water District of Southern California built the Colorado River Aqueduct from the Colorado River. To the north, San Francisco brings water from Hetch Hetchy Valley in the Sierra Nevadas and east bay cities bring water from the Mokelumne River. The Federal Central Valley project and the California State Water Project move water hundreds of miles from areas of surplus water in the north to cities and farms in the south and west. Statewide about 86 percent of the water diverted from streams and pumped from the ground irrigates farmland, about 12 percent serves municipal and industrial needs, and about 2 percent satisfies other needs. The major water projects in California are shown on Figure 6.

The State Water Project.

1.33 The key legislation for construction of the State Water Project was the State Water Resources Development Bond Act (Burns-Porter Act), which was ratified in the November 1960 general election. This act authorized the sale of $1.75 billion in general obligation bonds as the primary financing. The project began service to the southern San Francisco Bay area in 1962, the San Joaquin Valley in 1968, and Southern California in 1971. SWP facilities extend from Plumas County in the north to Riverside County in the south. The SWP was planned and constructed to deliver 5,217,000 cubic dekametres (4,230,000 acre-feet) of water annually to service areas in Northern, Central, and Southern California. The 715 kilometer (444-mile) long California Aqueduct, which begins at the Delta Pumping Plant, is the principal conveyance facility of the overall project, which now includes 21 dams and reservoirs, 5 power plants, and 17 pumping plants.

1.34 The main storage facility is Lake Oroville in Butte County. Water released from the Oroville complex flows down the Feather and Sacramento Rivers and then into the network of channels of the Delta, where it contributes to Delta uses, salinity control, and export needs south and west of the Delta. Lake Oroville, together with associated power and fish facilities on the Feather River, is operated for flood control, power generation, fishery enhancement, and water supply for local areas, the Delta, and export. Additional storage is provided by

Figure 6
MAJOR WATER
SUPPLY FACILITIES IN CALIFORNIA
EXISTING AND AUTHORIZED

the Federal-State San Luis Reservoir, and four reservoirs in Southern California.

1.35 At the northern base of the Tehachapi Mountains the A. D. Edmonston Pumping Plant lifts California Aqueduct water nearly 610 meters (2,000 feet) up the mountain. The water then crosses the mountains through a series of four tunnels. South of the Tehachapi Mountains, the aqueduct divides. The West Branch transports most of the water through Pyramid Reservoir to Castaic Lake, northwest of Los Angeles. The East Branch delivers water to the Antelope Valley and terminates at Lake Perris in Riverside County.

1.36 The 154 kilometer (96 mile) long Coastal Branch of the California Aqueduct would deliver water to San Luis Obispo and Santa Barbara Counties. Only the initial 26 kilometers has been constructed. The need and timing for extension to the two coastal counties is presently under study by DWR and the affected local agencies.

1.37 Operating the SWP requires large amounts of electrical energy. The amount is related to the quantity of water delivered. The project also generates energy, some of which is used for pumping and the remainder is sold to other utilities. DWR's existing energy supply arrangements are the result of contracts signed in 1966 and 1967, which provide for the purchase, sale, exchange, and transmission of energy until April 1, 1983. In 1975, the SWP required about two percent of all the electrical energy used in California, of which the Delta Pumping Plant used about 15 percent of the SWP requirements for pumping. The SWP's energy supply is obtained from an area encompassing most of the State of California and the Pacific Northwest.

1.38 The SWP is operated to maximize off-peak energy use and to minimize on-peak use. Under existing energy supply arrangements, on-peak hours are defined as 0700 to 2200 on weekdays and 1300 to 2200 on Saturdays. Operation is largely determined by the existing energy supply arrangements. DWR schedules off-peak operation of project pumps to minimize the cost of pumping water and because it is required by the existing arrangements. Under present conditions, off-peak energy can be obtained by using existing generating capacity most of the time and thus does not require the construction of new generating facilities.

<u>The Federal Central Valley Project</u>.

1.39 Investigation of the State's water needs and resources resulted in 1930 in the comprehensive State Water Plan, which proposed the transfer of surplus northern waters southward to areas of projected deficiency in the Central Valley. The initial units, known as the Central Valley Project (CVP) were authorized by the Federal Government in 1935 and undertaken by the Bureau of Reclamation. The existing CVP

reservoir systems providing Delta export supplies and augmenting low summer and fall flows to the Delta are the Shasta Division, the Trinity River Divison, and the Folsom Unit of the American River Division. Shasta Lake, located on the Sacramento River above Redding, regulates floods and stores surplus winter runoff for hydroelectric power generation, irrigation in the Sacramento Valley, maintenance of navigation and fish flows in the Sacramento River, recreation and Delta exports. These supplies are supplemented by diversions from the Trinity River Division. Clair Engle Lake and Whiskeytown Lake are the major reservoirs of the Trinity River Division. Folsom Lake regulates flows of the American River for flood control, power, irrigation, municipal and industrial use, fish and wildlife, and recreation. San Luis Reservoir and associated pumping and generating plants are joint-use facilities of the CVP and the State Water Project. Water diverted from the Delta at the Tracy and Delta pumping plants is pumped southward to San Luis Reservoir primarily during the winter and spring for release to service areas during the summer and fall.

1.40 Two major CVP dams are under construction, Auburn Dam on the American River and New Melones Dam on the Stanislaus River. Auburn Reservoir of the CVP's Auburn-Folsom South Unit would supplement Folsom Lake in providing flood control, power generation, diverting water for use in the Folsom South Canal Service Area, fish and recreation flows in the American River, and Delta inflows and exports. However, completion date of this project is presently uncertain. The Folsom South Canal is only partially completed. New Melones Reservoir, also under construction, will be operated for flood control, local water needs, power, fishery enhancement, and water quality control for San Joaquin River inflows to the Delta.

1.41 The major conveyance facility of the CVP is the Delta-Mendota Canal, which diverts water from the Delta at the Tracy Pumping Plant and transports it southward to San Luis Reservoir and various service areas. Delta-Mendota Canal flows also replace the natural flows of the San Jaoquin River which are stored at Millerton Lake and distributed north and south at higher elevations by the Madera and Friant-Kern Canals. The Contra Costa Canal also diverts water from the Delta to serve industries and municipalities in portions of Contra Costa County. Two major conveyance facilities of the CVP are under construction, the Tehama-Colusa Canal in the western Sacramento Valley and the Folsom South Canal (completion of construction is related to Auburn Dam and resolution of several other matters) in eastern Sacramento and San Joaquin Counties. The San Felipe Unit (42) is authorized to serve portions of Santa Clara, San Benito, Santa Cruz, and Monterey Counties from the San Luis Reservoir with water exported from the Delta.

1.42 Thirty miles south of Sacramento, the Delta Cross Channel helps to provide for the regulated passage of Sacramento River water through the Delta channels to the pumping plants of the Delta-Mendota Canal and Contra Costa Canal.

1.43 Over 60 agencies have contracts or commitments with the CVP for long-term water supplies from the Delta. CVP exports have been projected at 5.4 million cubic dekameters (4,400,000 acre-feet).

Statutes, Agreements, and Programs Related to Operation of the Delta Complex.

1.44 Statutes: The Delta Protection Act, Water Code Sections 12200et seq., has made certain obligations of the State with respect to the Delta very explicit. The Act requires that the State, in cooperation with the United States, provide salinity control and an adequate water supply for reasonable uses of water in the Delta. The Delta needs protected by the Act include consumptive uses such as agricultural, municipal, and industrial use, and inplace requirements such as those for fish, wildlife, recreation, and other envirnomental values. Substitute facilities may be provided in the Delta in lieu of salinity control if it is in the public interest and if there is no increased financial burden on the Delta water users solely because of such substitution. The Act gives the Delta users a priority to purchase SWP water when reasonable needs exceed vested rights.

Other sections of the Water Code (10505and 11460 to 11463) included in the Delta Protection Act by reference, set forth restrictions and limitations to protect the water requirements of the county of origin or the watershed wherein water originates. The Burns- Porter Act (Water Code Section 12931) later declared the Delta to be part of the Sacramento River watershed, thereby strengthening the Delta's priority.

1.45 Water Supply Contracts: The State, through DWR, has entered into longterm water supply contracts with 31 agencies, which encompass about one-quarter of the State's land area and contain about 65 percent of the State's assessed valuation and 69 percent of its population. Each contract' obligates the State to deliver a specified annual amount of State project water to the contracting agency. These annual entitlements are generally initially small, increasing each year thereafter until the maximum annual entitlement is reached. The combined maximum annual entitlements total 5,220,000 cubic dekameters (4,230,000 acre-feet) -- the amount established as the maximum which the State could contract to deliver. Table 1 shows the annual entitlements from 1967 to 1985 by major project service areas. The Feather River and North Bay areas, located north of the Delta Pumping Plant, have relatively small entitlements. Table 2 shows the actual and estimated SWP deliveries and other demands from 1967 to 1985. as extracted from Table 1 of DWR Bulletin 132-77 (18). The entitlement deliveries are less than total entitlement amounts shown in Table 1. For many contractors, the actual and currently projected municipal and industrial water needs are less than projected when the contracts were executed, largely due to reduced population growth.

1.46 SWP contracts provide for deficiencies in entitlement deliveries in water- short years, and for delivery of surplus water when available. Agricultural agencies in the San Joaquin Valley have been able to use substantial quantities of surplus water, and are expected to continue to request it as long as it is available.

TABLE 1
STATE WATER PROJECT, ANNUAL ENTITLEMENTS UNDER
LONG-TERM WATER SUPPLY CONTRACTS
(values in 1,000 acre-feet) a/

Calendar Year	Feather River Area	North Bay Area	South Bay Area	San Joaquin Valley	Central Coastal Area	Southern Calif. Area	Total
1967	0	0	12	0	0	0	12
1968	1	0	110	81	0	0	192
1969	1	0	99	168	0	0	268
1970	1	0	114	208	0	0	323
1975	2	0	124	557	0	740	1,423
1980	5	19	135	765	2	1,305	2,231
1985	19	33	146	1,079	25	1,912	3,214

TABLE 2
STATE WATER PROJECT
ACTUAL AND PROJECTED ANNUAL WATER DEMANDS
(values in 1,000 acre-feet) a/

Calendar Year	Deliveries to Contracting Agencies: Entitlement Water	Surplus Water	Other Deliveries b/	Total	Initial Fill	Losses & Storage Changes	Recreation Water	Total
1967	11.5	0	53.6	65.1	8.3	4.2	0	77.6
1968	171.7	121.5	14.8	308.0	498.9	117.9	0	924.8
1969	193.0	72.4	18.8	284.2	510.6	72.2	0	867.0
1970	234.0	133.0	38.1	405.1	23.9	2.4	0	431.4
1975	1,224.0	622.9	63.8	1,910.7	110.1	-94.6	3.4	1,929.6
1980	2,004.5	0 c/	180.5	2,185.0	0	131.0	7.8	2,323.8
1985	2,540.2	0 c/	151.3	2,691.5	0	132.5	23.9	2,847.9

a/ Metric conversion is acre-feet time 1.2335 equals cubic dekameters.
b/ Repayment water and regulated delivery of local supply. Values include conveyance of CVP water to Cross Valley Canal.
c/ Surplus deliveries are not projected in Bulletin 132-77.

1.47 Miscellaneous deliveries include the wheeling of CVP water through SWP facilities. This wheeling includes periodic exchanges for operational efficiency, and conveyance of CVP water to the Cross Valley Canal in Kern County under a contract with the Bureau of Reclamation. Also, DWR and the Bureau are presently negotiating for wheeling CVP water to the San Felipe service area.

Beyond 1985, DWR's current estimates of the rate of build-up in entitlement water demands are considerably lower than from contract amounts. The current estimates reflect potential water savings through water conservation and waste water reclamation, as well as slower rates of population growth. Estimated savings through water conservation and waste water reclamation increase from 8,600 acre-feet in 1980 to 600,000 acre-feet in the year 2000.

Delta Water Quality Constraints (Revised 8-18-78):

1.48 Water quality standards to protect all reasonable, beneficial uses, including fish and wildlife, in the Sacramento-San Joaquin Estuary are established in two ways:

1. By conditions in water right permits for the CVP and SWP issued by the State Water Resources Control Board (SWRCB); and

2. By water quality control plans established by SWRCB (pursuant to State and federal water quality control acts) and approved by the Environmental Protection Agency (EPA).

Implementing these standards requires the release of fresh water from the CVP and SWP reservoirs during the drier months of most years to push back the highly saline water of San Francisco Bay. In the interior Delta, criteria are also established for salts that occur through the use and reuse of water in and upstream from the Delta. Release of stored water from project reservoirs may be required to meet these as well.

1.49 In 1975 the SWRCB and the EPA approved water quality control plans for the San Francisco Bay Area and the portion of the Central Valley that includes the Delta. The 1975 Basin Plan objectives were modified several times in 1977 because of the drought. The modifications relaxed Delta standards, reduced outflow requirements, and conserved limited water supplies in upstream reservoirs. The modifications also limited exports and upstream diversions. CVP and SWP deliveries were substantially reduced from 1976 levels.

1.50 In August, 1978, the SWRCB, following hearings initiated in November, 1976 and release of draft reports in March, 1978, adopted a modified Basin Plan along with Water Rights Decision 1485. The new Plan has several significant changes from the 1975 Basin Plan. The most significant is that the new plan takes into account variations in

water-year types, recognizing that in wet years the projects have greater flexibility and can provide better conditions than were included in the old basin plan. It permits relaxations in water quality during water-short years when the projects have a minimum of flexibility and natural water quality conditions are degraded. This is reflected in all types of uses -- M&I, agricultural, and fish and wildlife. The plan's water quality objectives are very complex with many overlapping controls. In the area of fish and wildlife, the new Plan generally follows the criteria proposed in the Draft Four Agency Fish Agreement between DWR, USBR, the California Department of Fish and Game, and the U.S. Fish and Wildlife Service. In addition to flow requirements, CVP and SWP exports are limited in May, June, and July for striped bass protection.

1.51 CVP-SWP Coordinated Operation: The SWP and CVP water supplies are physically commingled in the Sacramento River system and in the Delta, and the San Luis storage and conveyance facilities are joint use. Day to day operational coordination is carried out under the principles set forth in an unsigned agreement negotiated in 1971, which supplements a May, 1960 agreement on the same subject. Each year since 1971 DWR and USBR have entered into annual letters of agreement to operate the projects according to the 1971 agreement. These agreements provide for the sharing of water and power, surplus supplies and/or transportation capacity, and the necessary bookkeeping arrangements. Execution of a long-term coordinated operating agreement is contingent upon the resolution of issues concerning the CVP's obligation to help meet Delta water quality standards and the preparation of an EIS.

1.52 The 1971 agreement incorporates the November 19, 1965 water quality criteria, which represented an understanding reached between DWR, USBR, and certain Sacramento River and Delta agricultural interests. Compliance with the more recent and more stringent water quality standards is complicated by the differences in the policies and legal positions of the Bureau and DWR. These differences may have been resolved somewhat by the decision in the United States v California Case, which involved the authority of the SWRCB to impose conditions in Water Right Permits issued to the Bureau of Reclamation.

SWP Recreation.

1.53 The Davis-Dolwig Act, (Water Code Section 11900 et. seq.) requires that the State mitigate any adverse impacts of the SWP. It also declares that recreation and the enhancement of fish and wildlife resources are among the purposes of state water projects. It stated that costs incurred for the latter purposes shall not be included in the charges for water and power, but shall be nonreimbursible. DWR was assigned the responsibility of planning for these purposes and for acquiring any needed lands, in coordination with the Departments of Parks and Recreation and Fish and Game. In 1966, the Davis Dolwig Act

was amended to provide up to $5 million annually of State oil and gas revenues for repayment of capital costs of dams and reservoirs allocated to these purposes and for specific recreation land costs. In 1968, the Act was again amended to authorize the Wildlife Conservation Board to construct public fishing access sites at SWP aqueducts.

1.54 In 1970, the Legislature and the people of California approved the Recreation and Fish and Wildlife Enhancement Bond Act (Water Code Section 11922 et. seq.), which authorized the issuance of $60,000,000 in general obligation bonds to finance construction of recreation and fish and wildlife enhancement facilities at units of the SWP. The Nejedly-Hart State, Urban and Coastal Park Bond Act of 1976 (Public Resources Code Section 5096.111 et. seq.) provides, among other things an additional $26 million for such purposes. About $21 million of this will be used by the Department of Parks and Recreation, the Departments of Navigation and Ocean Development and DWR at SWP reservoirs. In addition DWR has $5 million to build recreation facilities.

Figure 7 shows existing SWP recreation developments which are supported by water conveyed through the Delta Pumping Plant.

Ecological Study Program.

1.55 An Ecological Study Program on the SacramentoSan Joaquin Estuary is being conducted cooperatively by DWR, USBR, the Department of Fish and Game and the U.S. Fish and Wildlife Service under an agreement executed in July 1970. The agreement was based on a recognition that operation of the SWP and CVP has an impact on fish and wildlife in the Estuary, and that a more thorough understanding of resource requirements was necessary to define design and operating criteria for the projects. The Program's major elements are:

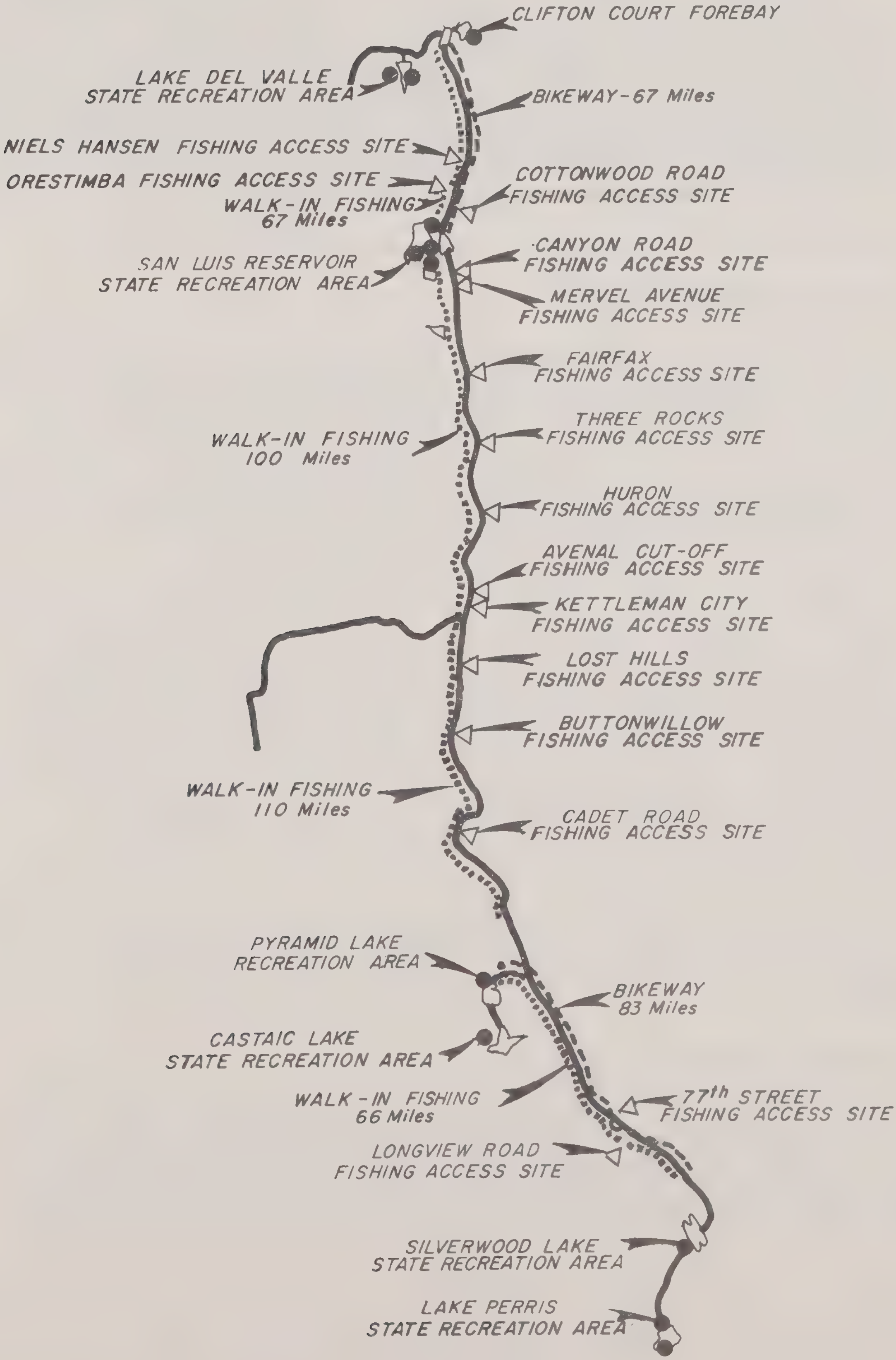
1. Bay Delta Fisheries Studies to define environmental requirements for the various species of fish and their food organisms.

2. Central Valley Salmon Program is part of a long term program to manage salmon and steelhead resources in the Estuary and tributary streams.

3. Water Quality Program to predict (a) water quality changes in the Delta flow patterns caused by water development projects and (b) the resulting effects on fish productivity.

4. Fish Facility Program to develop biological and engineering information for planned fish protective facilities. The element includes evaluation of existing fish screen facilities.

Figure 7 AQUEDUCT RECREATION DEVELOPMENTS



5. Suisun Marsh Program to develop a plan to preserve and improve wildlife habitat in the Suisun Marsh. Annual progress reports on the Program have been published since 1972, and detailed reports on various aspects are published from time to time.

1.56 As part of this Program, operation of the Delta Complex has been modified on several occasions to conduct fish tests. The Program also includes the Old River Closure, which involves the annual installation by DWR of a temporary barrier at the head of Old River to increase flows down the San Joaquin River and reduce dissolved oxygen deficiencies near Stockton during the fall salmon run.

This program will be expanded to meet the requirements of D-1485.

Long Range Energy Program.

1.57 DWR has a Long Range Energy Program to provide an assured energy supply commencing April 1, 1983, with minimal effects to the environment consistent with minimizing the cost of energy for SWP pumping. The program does not propose the construction of specific physical projects, but it includes a planning procedure for selecting and developing additional energy sources. DWR has prepared a Program EIR (26) to inform the public of the Program and the potential significant environmental effects of Program actions.

1.58 The basis of the program is that all energy resources available to the SWP plus additional resources selected or developed through the Program's planning procedure, would be coordinated with electric utilities in the region. Supplemental capacity and energy (primarily offpeak energy) would be purchased as needed from the utilities, and any SWP developed capacity and energy temporarily in excess of Project needs would be sold to the utilities. The Program would minimize the consumption of natural resources through coordination of project generation with regional generation, and by load management (coordination of project energy uses among plants) to reduce total project on-peak energy demands.

Under the programs planning procedures, DWR is presently pursuing and evaluating a wide range of future energy sources, including geothermal, solar, wind, cool, and biomass (agricultural and forestry wastes).

Delta Alternatives Program.

1.59 In the spring of 1975, DWR began a comprehensive review of the proposed Peripheral Canal and related statewide water issues. The basic objective of this "Delta Alternatives Program" was to find the best way to protect the Delta environment while supplying water to meet needs in the SWP and CVP service areas that receive water from

the Delta. The scope of the study included not only alternative facilities to transfer water across the Delta, but also numerous facilities both north and south of the Delta and legal and institutional measures that would affect the Delta. A report on this study will be released soon. As a result of this program, the Peripheral Canal and several other storage and conveyance facilities were adopted into the State's future program.

1.60 The proposed Peripheral Canal would replace the existing Delta channels as the means of conveying CVP-SWP water supplies across the Delta. The existing Clifton Court Forebay and the Delta and Tracy Pumping Plants would then be part of an integrated Delta system.

2.00 ENVIRONMENTAL SETTING WITH THE PROJECT.

2.01 The areas affected by operation of the Delta Complex are: (a) the Sacramento-San Joaquin Delta Region, (b) Suisun Marsh, (c) the San Francisco Bay Complex, and (d) the SWP export service areas. The Delta, Suisun Marsh and Bay areas are also affected by numerous other water projects, which modify natural flows into the Delta or which divert from the Delta. Presently, net water use in and above the Delta averages about 8 million acre-feet annually. Detailed descriptions of the environment in the Delta, Suisun Marsh, and Bay Complex (Figure 8) are available in the Draft EIR, on the Peripheral Canal Project (28) and the SWRCB's recent EIR (39).

Sacramento, San Joaquin Delta.

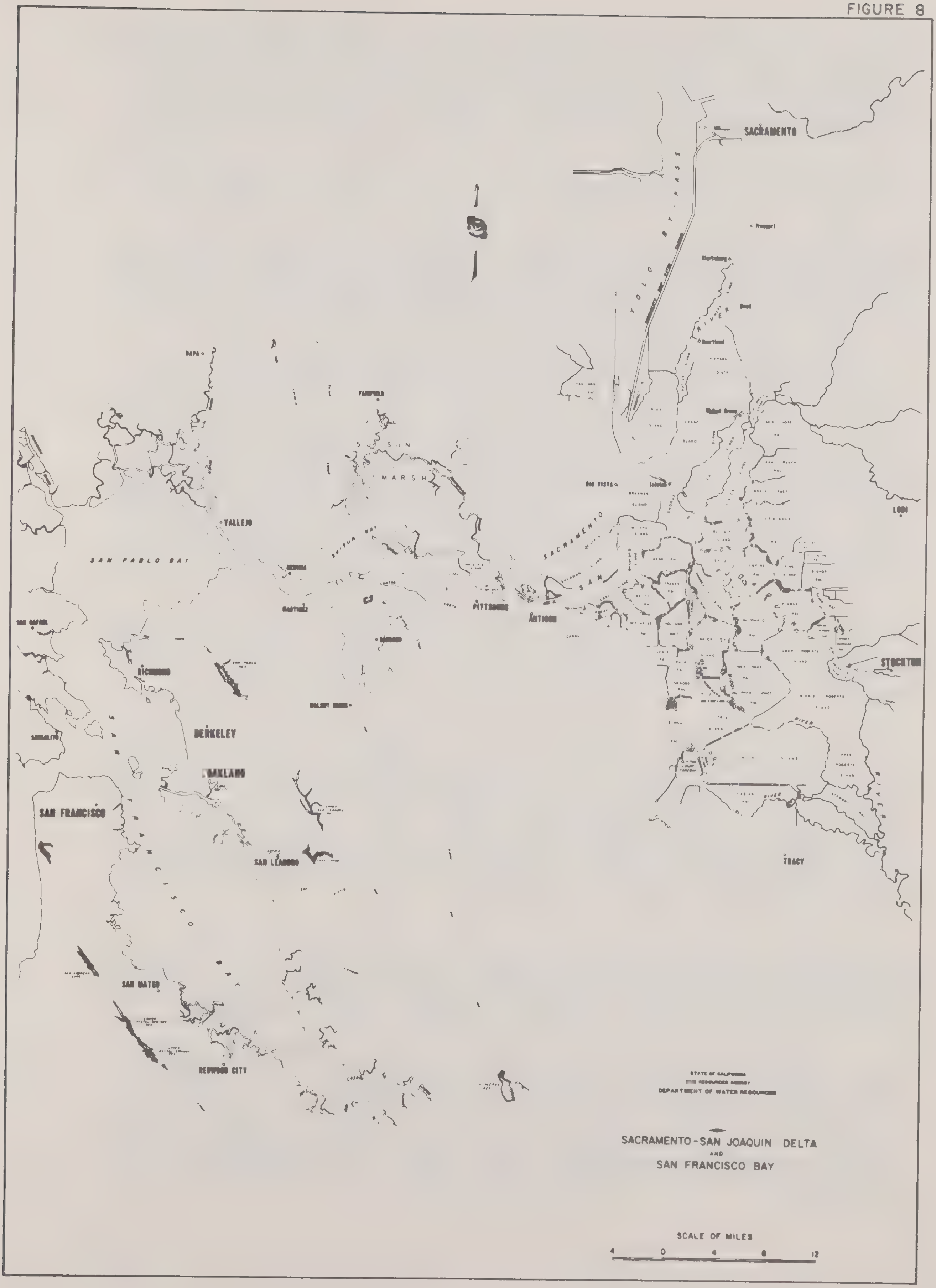
2.02 The area now occupied by the Delta Complex encompasses the southwestern edge of the Delta at Clifton Court Forebay and extends 4.2 kilometers southerly into the foothills of the Coastal Range, generally along the right of way of the Intake Channel and the discharge lines of the Delta Pumping Plant. The total area with the project rightofway is about 1,420 hectares (3,500 acres).

The climate in this area is typical of the Sacramento Valley, with hot dry summers and cool moist winters. Moderate to strong winds are common during the summer. These winds, coming through Altamount Pass from Castro Valley, can cause relatively large waves on Clifton Court Forebay and affect project operation.

2.03 Byron Road and the adjacent Southern Pacific Railroad is the main transportation corridor in the area, generally separating Clifton Court Forebay from the foothills. Other county roads in the area are Christenson Road, Byron Hot Springs Road, Haley Road, and Clifton Court Road.

2.04 The public water ways immediately east of the Forebay are West Canal and Old River. They are used for fishing and recreational boating. Nearby water ski and yacht clubs support these activities. The Delta Mendota Canal extends westward from Old River to the Tracy Pumping Plant along the south edge of Clifton Court. Along the north and west edges of Clifton Court Forebay, Italian Slough is used for fishing and some water skiing, in addition to providing an irrigation supply to several local diverters.

2.05 Prior to the construction of the Complex, the site of Clifton Court Forebay was called Clifton Court Tract. It was first reclaimed in 1899. These flat lowlands were protected from the waters of Old River, Italian Slough, and West Cut by levees about 4 meters high at the north end merging into high ground at the south end. They were used almost exclusively for growing a wide variety of crops, primarily asparagus and safflower.


SACRAMENTO
YOLO BY-PASS
RIVER
NAPA
FAIRFIELD
SUISUN
MARSH
RIO VISTA
VALLEJO
SAN PABLO BAY
SUISUN BAY
SACRAMENTO
SAN
PITTSBURG
ANTIOCH
LODI
STOCKTON
SAN RAFAEL
RICHMOND
BERKELEY
SAUSALITO
OAKLAND
SAN FRANCISCO
SAN FRANCISCO BAY
SAN LEANDRO
TRACY
RIVER
SAN MATEO
REDWOOD CITY
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SACRAMENTO-SAN JOAQUIN DELTA
AND
SAN FRANCISCO BAY
SCALE OF MILES
4
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12

2.06 Lands acquired for the Intake Channel, Pumping Plant, Operation and Maintenance Center, and access roads were generally rolling hills used primarily for grazing of sheep and cattle. A small portion of the land was irrigated pasture and alfalfa. There were two occupied residences. Other improvements were barns and other animal shelters, storage buildings, corrals, shallow wells, windmills, water tanks, and water troughs. The ByronBethany Irrigation District supplied (and continues to supply) irrigation water to the foothill lands.

2.07 Clifton Court Tract provided a resting area for migrating birds and supported populations of doves, pheasants, and quail. Recreation use in the tract was negligible; being restricted mostly to hunting and bank fishing by landowners and their friends.

2.08 Over the years, the swamplands of the Delta have been transformed by man into more than 50 reclaimed islands and tracts largely devoted to farming. Approximately 550,000 acres of cultivated land within the Delta produce an average gross annual income of 195 million dollars. The 738,000 total acres within the Delta are interlaced with about 700 miles of waterways that meander among the reclaimed islands. These islands, many of which lie below sea level, are protected from floods and high tides by manmade levees, and are subject to seepage from surrounding channel waters. Although most of the Delta is devoted to agriculture, upland areas, particularly in the western Delta, have undergone steady industrialization and urbanization. Delta waterways constitute a rich repository of aquatic life, nourish a wide variety of fish and wildlife, and provide a major recreation area for fishing, boating, water skiing, hunting, and scenic enjoyment.

2.09 Although land reclamation of the former marshlands has removed much of the once lush expanses of native vegetation, the Delta remains a habitat for a multitude of fish and wildlife species. Salmon, shad, and steelhead migrate through the Delta. The estuary provides important habitat for striped bass. The Delta contributes 20 percent of the pheasants harvested in the State. Ten rare and endangered vertebrate species are known to occur in the Delta, but none of them are confined exclusively to that area.

2.10 The Sacramento-San Joaquin Delta region is within the area bordered by the Cities of Sacramento, Stockton, Tracy, and Pittsburg. Although the total population of the region reached 1.7 million in 1970, the Delta islands, themselves, remain sparsely populated.

2.11 The Delta plays a key role in the management of Calfornia's water resources. While the major sources of water are in Northern California, the major urban and agricultural lands needing water are in the central and southern portions of the State. Approximately 75 percent of the total streamflow occurs north of Sacramento and 25 percent south. About 80 percent of projected urban and agricultural

water requirements lie south of Sacramento. The season of highest demand for water is summer, while most precipitation and runoff occurs in winter and spring. Further, the large variations of runoff that occur from year to year contribute to California's water management problems.

Suisun Marsh.

2.12 The Suisun Marsh is located on the northern edge of Suisun Bay a few miles below the junction of the Sacramento and San Joaquin Rivers (see Figure 8). It contains 22.200 hectares (55,000 acres) of brackish water marsh that provides wintering area for over 20 percent of the ducks and other waterfowl using the Pacific Flyway. About 11,300 hectares (28,000) acres of channels and bays within and adjacent to the marshlands are important habitat for many kinds of fish.

2.13 About 80 percent of the marsh is privately owned by over 150 duck clubs. The remaining area is owned and operated by the California Department of Fish and Game for waterfowl management, refuge, and public recreation areas. The recently enacted Suisun Marsh Preservation Act of 1977 (Public Resources Code Section 2900 et. seq.) provides for compatible land uses in and around the Marsh and for public acquisition of certain valuable lands.

2.14 Waterfowl are attracted to the marsh primarily because of the presence of water and the abundance of natural food plants. More than 180 species of plants occur in the marsh, and about 20 percent of these regularly appear in the diet of ducks. The three most valuable waterfowl food plants are alkali bulrush, fat hen, and brass buttons.

2.15 One of the most influential environmental conditions affecting waterfowl food production is the soil salt concentration. Both high and very low levels of soil salinity encourage plants of low food value, while moderate salinity levels favor the valuable food plants. Research and experience have shown that salinity concentrations in the first foot of soil during the spring are critical to waterfowl food plant.

2.16 Most of the marsh has been leveed into a series of large shallow ponds. Soil salinity levels are adjusted by leaching, opening levee gates to flood ponds on high tides and subsequent draining when tides are low. Initial flooding is done in the early fall before most of the waterfowl arrive. In late January when fresher water is available, most ponds are drained and reflooded, repeatedly to leach out salts brought in during fall flooding. Management frequently includes final flooding and retention of water in ponds during April and May. Total dissolved salt levels in the first foot of soil can thus be reduced to 7 to 9 parts per thousand to permit high seed production of the most valuable food plants. In June the ponds are

drained for mosquito control and to discourage the growth of cattails and freshwater bulrushes. Freshwater outflows from the Delta into Suisun Bay and the Suisun Marsh channels are critical to the marsh.

San Francisco Bay Complex.

2.17 The San Francisco Bay Complex comprises portions of all nine surrounding counties and includes San Francisco, San Pablo, Suisun, Grizzly, and Honker Bays. The entire estuarine complex covers almost 1126 square kilometers (435 square miles) and is rimmed by 443 kilometers (275 miles) of shoreline at mean sea level. Tidal marshlands up to 5 kilometers wide border much of south San Francisco Bay, the northern perimeter of San Pablo Bay and much of Suisun Bay. Most of San Francisco Bay is shallow, about 70 percent being less than 6 meters deep. The tidal flow maintains a system of deeper channels branching out north and south of the main channel at the Golden Gate. The other bays are mostly shallow. For example, most of Suisun Bay is less than 2 meters deep, but the main channel is 5 to 21 meters deep.

2.18 The bay complex is among the most urbanized areas in the State, with a total 1970 population of 4.6 million. Its water requirements are met from local resources and importations via the Hetch Hetchy, Mokelumne River, and South Bay Aqueducts and the Contra Costa Canal. Ground water supplies are an important source of freshwater in localities such as the Santa Clara and Livermore Valleys and the bay plain area of Alameda County.

2.19 The habitat afforded by the Bay System supports a wide variety of fish and invertebrates. Popular sport fish include striped bass, surfperch, jacksmelt, and topsmelt. Shell fish include mussels, oysters, clams, crab, and shrimp. Seasonal variations of salinity in the bays affect the seasonal distribution of fish and invertebrates and, in some cases, the survival of invertebrates, particularly clams.

2.20 The bays and surrounding lands support a wide variety of resident and migratory birds and mammals. Water oriented recreation activities include sightseeing, picnicking, boating, nature walking, and camping. Swimming, and water skiing take place where water quality permits.

2.21 The volume of water in the Bay system is approximately 6 cubic kilometers (5 million acrefeet) at mean tide. Between high and low tides, which occur twice a day, the average difference or tidal prism is 1.4 cubic kilometers (1.1 million acrefeet). About onequarter of this tidal prism is exchanged with new ocean water during each 12.4hour ebbflood tidal phase.

2.22 The largest surface freshwater inflow to the Bay complex is that provided by runoff from the Central Valley (Delta outflow), which has been estimated to range from a maximum of 53 cubic kilometers (42.9 million acrefeet) annually to a minimum of 7 cubic kilometers (5.7 million acrefeet). About 74 percent of the annual total usually occurs from January through May. In addition to flows from the Delta, a number of smaller streams are tributary to the Bay. The seven major streams, which drain about 60 percent of the tributary area, are Alameda Creek, Napa River, Coyote Creek, Guadalupe River, Walnut Creek, San Lorenzo Creek, and Sonoma Creek. Their flows vary from negligible amounts during the summer to high winter maximums.

2.23 The quality of the Bay water depends upon the balance between the rate with which pollutants are added to the estuary and the rate at which they are removed by tidal action, surface reaeration, and freshwater inflows. Waste water, whether municipal, industrial, agricultural, or storm water, is a complex mixture of many different types of pollutants. Although the waters of the bay are relatively "clean" in comparison with waterways in other parts of the country and of the world, degradation does exist in some area (9). For example, many shallow areas of the Bay have been posted to prevent shellfishing and water contact recreation. These restrictions were necessary because of high concentrations of coliform bacteria attributed to municipal waste water discharges and, to a lesser degree, storm water runoff. There have been fish kills in the bay, some of which have been traced to industrial (cyanide) and agricultural (herbicide) discharges. Low diversities of bottom dwelling (benthic) organisms have been found in certain areas of the Bay. These were found to correlate with local municipal and industrial waste water relativetoxicity loads. The highest concentrations of toxic metals in bottom materials have been found in the Suisun Bay and San Pablo Bay areas when industrial discharges are prevalent. Although dissolved oxygen concentrations are generally satisfactory, concentrations in several shallow areas of the Bay and tidal influenced reaches of the Napa and Petaluma Rivers have historically undergone large fluctuations and fallen below prescribed water quality objectives. The biochemical oxygen demands (BOD) from municipal waste water discharges have been identified as the major cause of the problem. Extensive algal concentrations have been detected in localized areas of South San Francisco Bay and Suisun Bay. The high concentration of biostimulants in waste water discharges in conjunction with sunlight, high water temperatures, long detention time, and other factors are considered the primary causes. There have also been nuisance conditions of odor and floating material atributable to waste water discharges. Various oil spill incidents have been documented.

Export Service Areas.

2.24 The Delta Complex diverts water from the Delta for delivery to the South Bay area, the San Joaquin Valley, and Southern California.

San Joaquin Valley deliveries include CVP water conveyed through the SWP system and the Cross Valley Canal in Kern County (64) Figure 9 shows the three SWP Service areas and the contracting agencies therein. More detailed information on the setting in these service areas is available in a Supplemental Report (1).

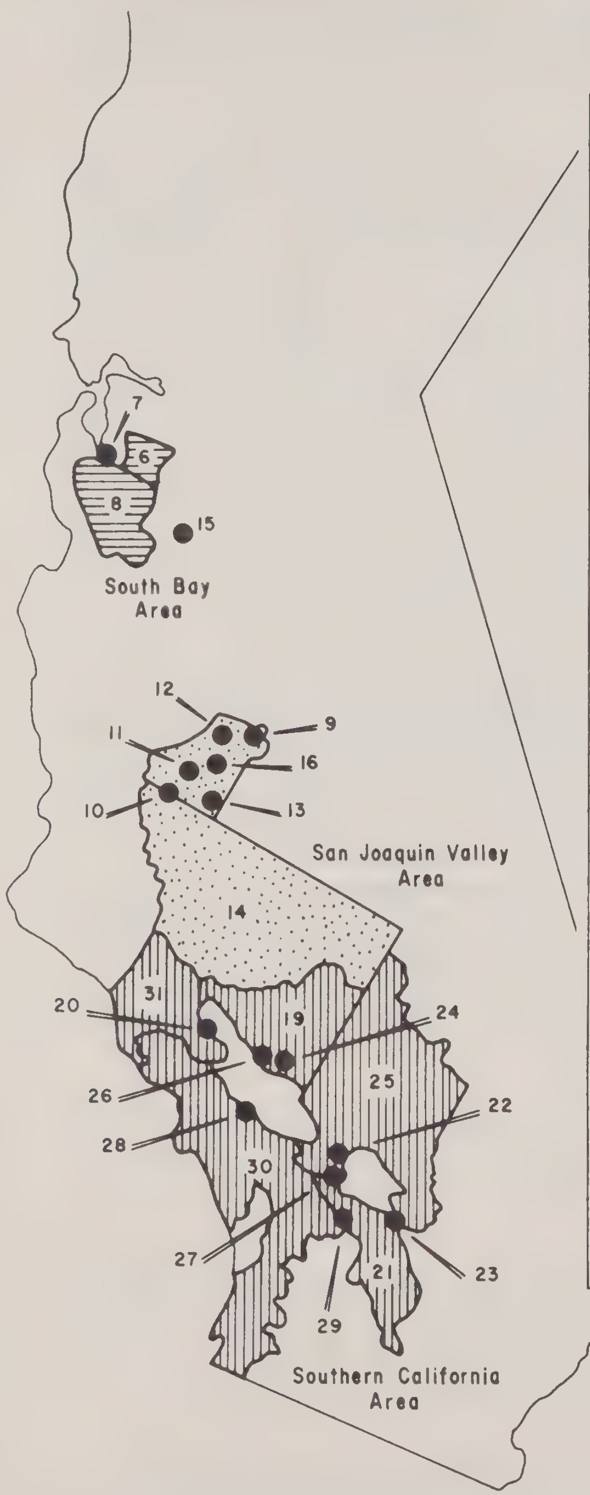
The South Bay Service Area is located in Santa Clara County and the Southern part of Alameda County. It has a gross area of 1,182,700 acres. In 1975, about 12 percent was classified as urban and suburban, 5 percent as agricultural, and the remaining 83 percent as undeveloped open space. Population was about 1,478,000 and total employment was 558,800, with 30 percent in manufacturing and 20 percent in services. In the period 1975 to 1980, it is anticipated that agricultural land use will be reduced by 1650 acres, and that residential use will increase by 42,900 acres. By 1980, population is expected to increase to 1,647,200 and employment to 648,000.

2.25 The San Joaquin Valley Service Area is located primarily in Kern and Kings Counties. A small portion of Stanislaus County is also served. Kern and Kings Counties are located in the Tulare Lake Basin, a hydrologically closed basin at the southern end of the valley. The economy of Kern and Kings Counties, as well as other San Joaquin Valley counties to the North, is based to a large extent on agricultural production and agriculturally oriented industries and services. In 1975, about 385,163 acres in the San Joaquin Valley were irrigated with State water (30). This represents about 60 percent of the total irrigated acreage that year in the State service area. The estimated population of Kern County within the SWP service area was 300,800 in 1975, of which one-fourth was in Bakersfield. This population is expected to increase to 326,000 in 1980.

Gross farm receipts in excess of two billion dollars are realized annually. The total annual farm income of the eight San Joaquin Valley counties exceeds the annual farm income of 47 of the 50 states. The eight valley floor counties contribute more than eight billion dollars to the State's gross annual product.

2.26 With the long growing season and the changes in climate and soils from north to south and east to west, a wide variety of agricultural products are produced. Truck crops, deciduous fruits and nuts, citrus fruit, rice, sugar beets, cotton, and vineyards are included among dominant crops. At present 200,000 acres are urban lands; 4,100,000 acres are irrigated land areas; 3,400,000 acres are potentially irrigable; and 100,000 acres are classified as fish and wildlife areas.

2.27 Essentially all of the surface water supplies for the San Joaquin Valley are obtained from streams originating in the Sierra Nevada and their foothills and diversions from the Delta. A portion of the region's surface water supplies is diverted to the San



No.	Contracting Agency
	SOUTH BAY AREA
6	Alameda County Flood Control and Water Conservation Dist., Zone 7
7	Alameda County Water District
8	Santa Clara Valley Water District
	SAN JOAQUIN VALLEY AREA
9	County of Kings
10	Devil's Den Water District
11	Dudley Ridge Water District
12	Empire West Side Irrigation District
13	Hacienda Water District
14	Kern County Water Agency
15	Oak Flat Water District
16	Tulare Lake Basin Water Storage District
	SOUTHERN CALIFORNIA AREA
19	Antelope Valley-East Kern Water Agency
20	Castaic Lake Water Agency
21	Coachella Valley County Water District
22	Crestline-Lake Arrowhead Water Agency
23	Desert Water Agency
24	Littlerock Creek Irrigation District
25	Mojave Water Agency
26	Palmdale Water District
27	San Bernardino Valley Municipal Water District
28	San Gabriel Valley Municipal Water District
29	San Gorgonio Pass Water Agency
30	The Metropolitan Water District of Southern California
31	Ventura County Flood Control District

Figure 9 LONG-TERM WATER SUPPLY CONTRACTING AGENCIES

Francisco Bay area through the HetchHetchy system of the City and County of San Francisco. Ground waters are extensively used as a source of water supply for agricultural, municipal, and industrial purposes.

2.28 The west side of the San Joaquin Valley is characterized principally by a semiarid climate, irrigated agriculture, oil fields, grasslands, seasonal marshland, relatively sparse native, semidesert vegetation, a low human population density, and substantial open space.

2.29 The value of existing agricultural lands for wildlife habitat depends largely upon the crop produced and farming practices. Grains and cultivated crops offer productive habitat for pheasants, waterfowl, and some nongame wildlife species.

2.30 Native vegetation is dominated by annual grasses, saltbrush, and valley mesquite, which supports moderate population of upland game and many nongame birds and mammals. Moderate deer populations are located in the Coast Range foothills bordering the valley floor.

2.31 The Southern California Service Area includes all or part of eight counties: Ventura, Los Angeles, Orange, southeastern Kern, southwestern San Bernardino, western Riverside, western San Diego, and a small section of Imperial. The gross water service area was about 1,988,000 acres in 1975, with about 1,396,000 acres in urban use and 592,000 acres irrigated. The population in 1975 was about 11,966,000, and employment 4,573,000, with 42 percent in manufacturing and services. In 1980, the water service area is expected to increase to between 1,497,000 and 1,527,000 acres. Most of this increase will be in urban and suburban areas. Population in 1980 is projected at 12,863,000, a 7 percent increase above that of 1975. Employment in 1980 is projected at 5,297,000, a 16 percent increase above that of 1975.

2.32 The area's climate is arid and its temperatures are mild, with increasingly warmer weather inland. Though precipitation in the plains is usually sparse, the mountains have moderate amounts of rainfall during the winter.

2.33 This area is highly urbanized along the coast, with many of its industrial centers in the coastal plains. Major industrialization has recently overshadowed the economic importance of the area's agriculture. Coastal recreation areas, in particular, are at a premium and are heavily utilized.

2.34 In each of the three service areas, SWP supplies supplement previously developed local ground and surface supplies and imports. Each of the three areas has historically met supply deficiencies through ground water overdraft. Other major water projects which provide the service areas with imports are the Hetch Hetchy Aqueduct

for the South Bay area, the FriantKern Canal for the San Joaquin Valley, and the Colorado and Owens River Aqueducts for Southern California.

2.35 The SWP service areas overlie some of the most highly developed ground water basins in the State. As increased pumping lowered the ground water levels in these basins, some were overdrafted and the severity of associated problems increased. Such problems included the need to deepen wells, increasing energy costs, intrusion from adjacent saline or brackish water, and land subsidence. The latter problem has been notable in the western and southern portion of the San Joaquin Valley and at San Jose in the South Bay area. Subsidence in the South Bay area has required repair or replacement of many private and public facilities sensitive to changes in land elevation. Subsidence in the southwestern portion of the San Joaquin Valley has caused damage to deep well casings.

2.36 In most of the Southern California basins, the ground water quality is suitable for all beneficial uses. In some basins, beneficial uses are limited by hardness and other water quality problems. In basins where Colorado River water is used for recharge, the ground water has begun to take on the qualities of the recharge water and is inferior for some uses to the natural water. Almost all of the Southern California basins are highly developed except in San Diego County, where the basins are less extensive, and in some cases, contain water unsuitable for domestic use.

2.37 Sea water intrusion occurs in several coastal ground water basins in Southern California and is a potential threat in all such basins when ground water levels are drawn down below sea level. Sea water intrusion has also occurred in the South Bay area near San Jose and Fremont.

3.00 THE RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE PLANS

3.01 The operation of the Delta Complex does not conflict with any known land use plans or the Delta Master Recreation Plan. The Delta Pumping Plant has been in operation since 1967, and land use plans formulated since that time have taken into account the existing facilities, water deliveries, and water supply contracts. The Delta complex was developed as an important part of the California Water Plan, (17) a master plan for the control, conservation, and distribution of the waters of California.

The Effects of Water Development in General.

4.01 The Delta is subject to the intrusion of saltwater by tidal action through San Francisco Bay. The amount of saltwater intrusion depends directly on the rate of Delta freshwater outflow. Very large winter flows sometimes push the saline water as far back as San Francisco Bay. During extreme dry periods, small summer flows have historically allowed the tides to carry saline water upstream almost to Sacramento and Stockton.

4.02 Salinity intrusion is controlled by Delta outflow, which is now augmented as necessary by SWP and CVP reservoir releases during low flow periods. These releases have been sufficient to keep ocean derived salts out of about 90 percent of the Delta.

4.03 Although the CUP and SWP have increased the net Delta outflow during certain times of the year and limited the extent of saline intrusion, the overall average annual Delta outflow has been decreased because of upstream uses, storage, and exports.

4.04 There are numerous diversions made from Delta channels for irrigation of about 202,000 hectares (500,000 acres) of Delta farms. Any diversion will draw fish and fish eggs and the larger the water diversion, the greater the loss. The largest individual diversions in the Delta are those at the Tracy and Delta Pumping Plants. The intake channels to these pumping plants have fish protective facilities which screen out most fish over about 4 centimeters (1.5 inches) in length, but are not very effective in intercepting the free-floating eggs of the striped bass and other fish that spawn in the Delta, and their food organisms.

4.05 The CVP and SWP pumps cause a reversal in the net movement of water in some Delta channels during low streamflow periods, as shown in Figure 10. Existing channel capacities limit the amount of water that can be transferred from the Sacramento River through the Central Delta to the CVP and SWP pumps. The Delta Cross Channel of the CVP and Georgiana Slough, a natural channel, allow some, but not enough during low-flow periods, water to pass across the Central Delta to the pumps. Consequently, there are times when large amounts of upstream water must reach the pumps by first flowing around Sherman Island at the western edge of the Delta, picking up ocean derived salts as it travels back up the San Joaquin River to the project pumps. Also, water in southern interior channels flows in a southerly direction to reach the pumps, contrary to the natural flow patterns. The net reverse flow of fresh water in southern Delta channels causes delays for fish in their spawning migrations. The effects of waste discharges in the vicinity of the San Joaquin River near Stockton, which are made more acute by flow reversals, cause an increase in

dissolved oxygen levels that are detrimental to fish migration. Furthermore, project water that does cross the Delta by way of the Delta Cross Channel and Georgiana Slough has a relatively short detention time in the Central Delta and thus does not provide for a satisfactory habitat for fish food organisms.

4.06 In addition to salinity intrusion, flow reversals, and fishery losses, which are interrelated, there are two other concerns regarding the SWP and CVP export pumps. (1) Nearby property owners, marina operators, and ski clubs have complained about scouring and siltation caused by the CVP and SWP diversions. (2) The diversions lower water levels near the intake. Agricultural, marina, and navigation interests are dependent upon minimum water levels during low tide conditions. Examples are: navigation charts show depths below mean low water, marina docks and ramps are not functional below normal low water levels, and irrigation pumps are generally set to operate between predictable water surfaces. Therefore, because exports affect water levels near the diversion intakes, SWP diversions into Clifton Court Forebay are restricted or eliminated during the low-low tide, but are increased over average rates during higher tides. On the other hand, CVP diversions are continuous throughout the tidal cycle, because that project does not have the capability of intermittent diversions afforded by the SWP's Clifton Court Forebay.

4.07 It is generally acknowledged that increasing upstream and Delta diversions, with resulting increases in the extent and duration of salinity in Suisun Bay, makes management of the Suisun Marsh more difficult. Improved management techniques and above normal runoff years have enabled marsh managers to cope with the problem. (The interim water quality objectives of 1977 provided only partial protection to the marsh, and the long-term effects of the drought remain to be seen.) Maintaining the desirable brackish water marsh is expected to become increasingly difficult in the future with further increases in diversions, unless the marsh is provided adequate quality water from some source other than Suisun Bay.

4.08 Once discharged into the San Francisco Bay complex, pollutants are removed primarily by tidal action. Freshwater outflows and surface reaeration are the other cleansing mechanisms. During the summer and other low flow periods, bay circulation patterns and flushing are controlled by tides. Under winter flood conditions, they are controlled by a combination of tides and freshwater outflows.

4.09 Operation of the CVP and SWP has a recognized impact on inflows to the bay complex. In general, the projects provide greater inflow in the summer and lesser winter inflow than would otherwise occur.

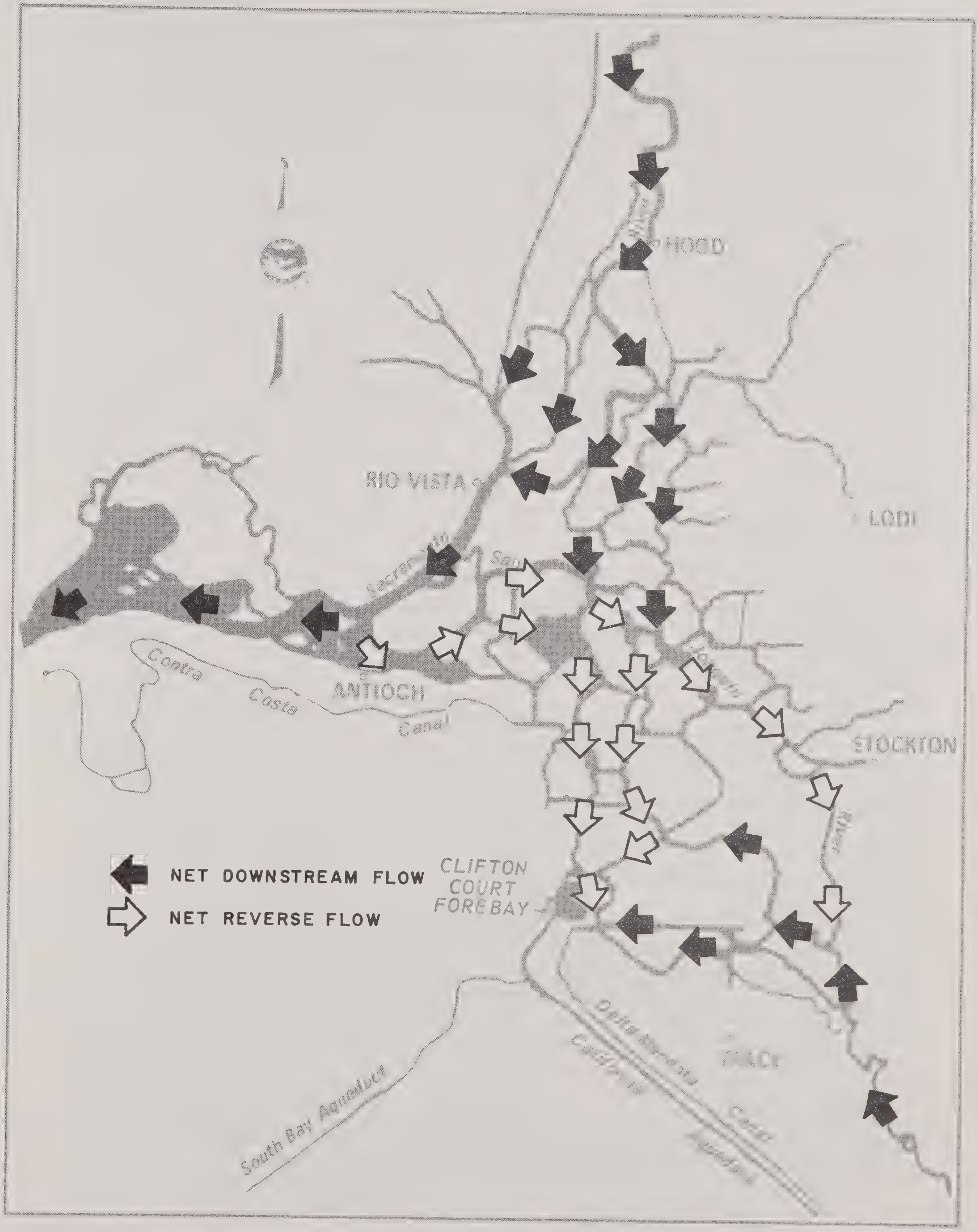


Figure 10 SUMMER FLOW PATTERNS IN THE DELTA
PRESENT CONDITIONS

4.10 A model test showed that the effectiveness of summer Delta outflow for flushing pollutants was most noticeable in the western Delta and Suisun Bay (38). A Threefold increase in summer outflow from 1,800 cfs to 5,000 cfs reduced pollutant levels from 10 to 40 percent effect in that area. The effectiveness of summer outflow flushing diminished in San Pablo Bay to 3 to 10 percent and became insignificant in the central and south bays.

4.11 During the winter, the water projects reduce flood peaks, but pass much of the floodwaters through on a slightly modified schedule. As upstream regulation is increased, the frequency and magnitude of winter flushing flows will be reduced. The effect of floodflows on flushing extend throughout the bay and are significant. Density stratification with its pronounced circulations can extend far into the south bay. During January 1970, the outflow from the Delta averaged about 175,000 cfs, and a well stratified condition was established throughout the south bay, with sudden and large reductions in salinity. This salinity reduction indicates that the flood waters were entering the south bay and could dilute and flush the pollutants that build up in the bay (47). In mid-December 1969, south bay was not stratified, even though the outflow for the previous three months had averaged about 17,000 cfs.

4.12 Pollutant buildup rates throughout the bay are sufficiently rapid so that the flushing action of winter floods cannot provide year-round protection against poor water quality. It takes about 1 to 3 months for pollutant concentrations to approach equilibrium steady-state conditions for a particular flow condition. Consequently, maximum pollution concentrations can be expected each summer regardless of the amount of flushing associated with density stratification produced by winter floods. The SWRCB has not established a requirement for flushing flows. Nevertheless, the concern remains that outflow reductions due to CVP-SWP operation may reduce the Bay's ability to flush away waste not controlled by regulation or treatment (5). At the present time, this impact of Delta water diversions must be considered as unknown.

4.13 Reduction of outflow may reduce nutrient contributions now carried to the Bay with river water. Such a reduction could alter biological productivity or change algae populations in a way that would be detrimental to fish or shellfish. However, during the drought years, 1976-77, low productivity during low flows was not due to nutrient limitation. Algal populations in the Bay Area are now dominated by diatoms which require silica. A large percentage of the silica available to them is contributed by river runoff. Reduction of that silica to limiting levels could cause changes in algae composition in the San Francisco Bay estuary, but this is unlikely to happen.

4.14 Another concern is that reduction of outflow may reduce the suspended sediment load now being carried into the Bay to the extent that the Bay waters will increase in clarity. The increase in light penetration may cause an increase in phytoplankton populations, which could cause dissolved oxygen fluctuations adversely affecting the fishery. Current results of water quality modeling indicate that while the reduction in turbidity might increase phytoplankton levels, the levels would not be harmful. During the drought-reduced outflows of 1976-77, turbidity levels were very low and light penetration increased greatly. However, phytoplankton levels did not increase and remained much lower than expected, despite low outflows. Although many studies were conducted, the reason for the unexpected low productivity is not fully understood at this time.

4.15 Many of the explanations concerning the physical, chemical, and biological relationships of the San Francisco Bay complex are only theoretical. Hopefully, more direct answers will be derived from ongoing studies conducted jointly by the USBR, USFWS, DFG and DWR.

Impact Assessment Studies for Delta Complex Operations.

4.16 Many effects of the Delta Complex were evaluated quantitatively for designated years of historic hydrology under present level of development. The years were critically dry (1934) above normal (1946), and wet (1967). Monthly SWP exports were determined by 1980-level operation studies (27) based on flows estimated to satisfy the Four-Agency Fish Agreement interim standards and the 1975 Basin Plan agricultural or minicipal and industrial objectives. Power constraints were also considered.

4.17 The exports for the above normal and wet years included requested surplus deliveries and Southern California ground water recharge (totaling 0.93 MAF) for the purpose of showing full usage of the existing Delta complex facilities. Thus, the exports for these years could be applicable to meet increasing entitlements for several years beyond 1980.

4.18 On the other hand, exports for the critically dry year occurring in the years immediately beyond 1980 could not be significantly increased because of the water quality constraints and the limited water supplies available. Thus the SWP exports used for impact assessment are considered representative of full capability with existing facilities under a range of hydrologic conditions. They are shown in Figure 11.

4.19 The effects of the SWP diversions were isolated from the many other factors affecting flows, water quality, and fish and wildlife in the estuary by comparison of "with delta complex" and "without delta complex" operation. The "without" condition assumed that monthly outflows from the Delta were augmented by amounts of flow

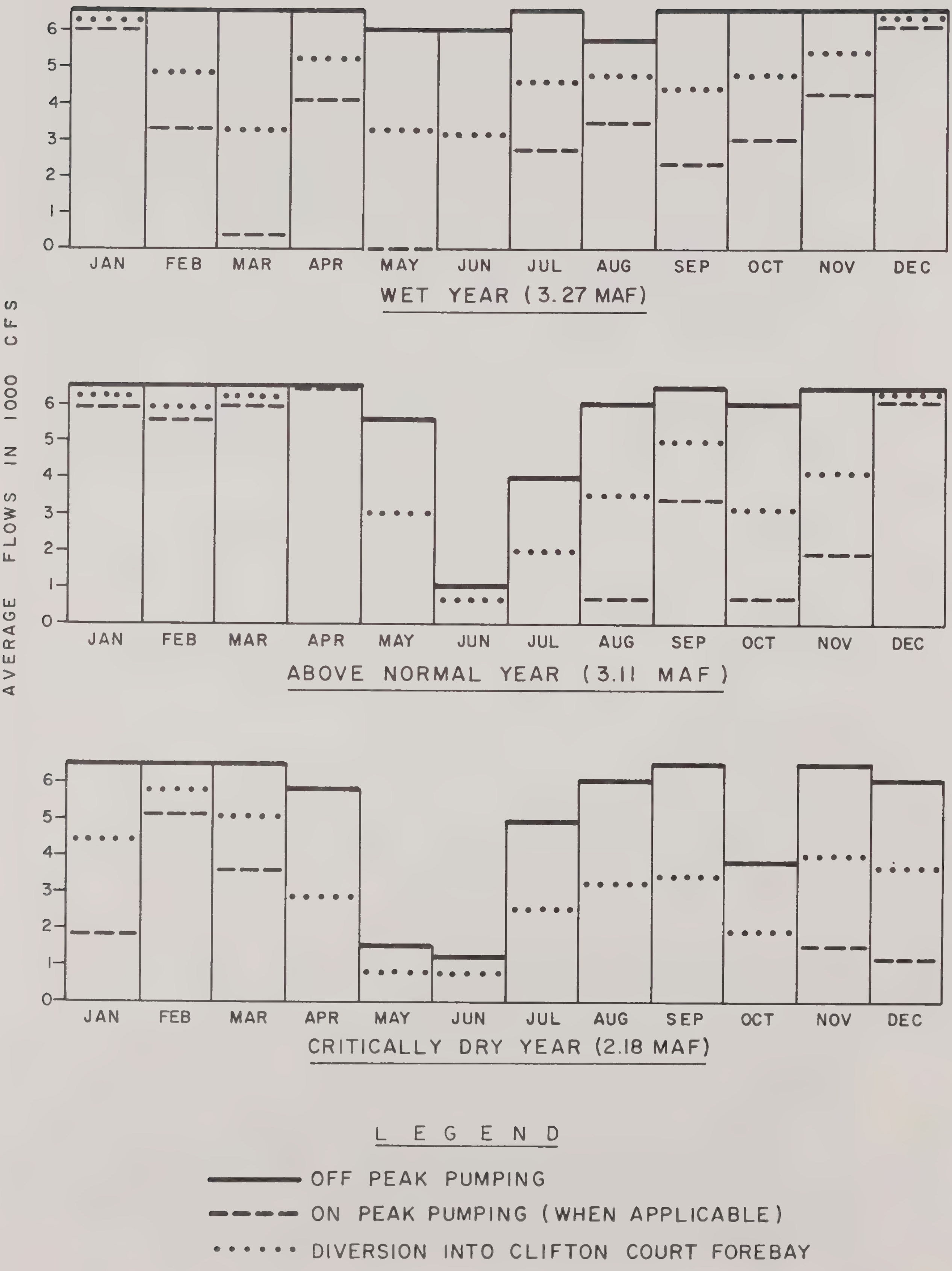


Figure 11 PUMPING AND DIVERSION RATES AT DELTA COMPLEX USED FOR IMPACT ASSESSMENT

corresponding to the monthly SWP diversions, with no changes in the operation of upstream reservoirs and no diversions from the Delta Pumping Plant. This approach to impact assessment does not reflect the overall impacts of the SWP, including Lake Oroville, but was considered responsive to the special needs of this EIS.

The impacts of Delta Complex Operation on the Sacramento-San Joaquin Delta.

4.21 Impacts on the adjacent area: The channel between Clifton Court Forebay and the Pumping Plant bisects the Byron Bethany Irrigation District and its irrigation canal. Consequently, the project included relocation of the District's pump diversions from Italian Slough to the channel. This change has been beneficial to the District from the standpoints of water service and water quality. The Italian Slough diversion was subject to interruption of service at low tides and mineralized waters due to drainage and seepage out of the District. Without construction and operation of the State facilities, the District would have had to substantially improve its irrigation system to provide service and water quality comparable to that now available. Prior to beginning operation of the Delta Pumping Plant, Italian Slough was a dead-end watercourse subject to irrigation drainage. With the advent of operation of the pumping plant, water circulation increased many-fold, with a commensurate improvement in water quality. However, when operation of Clifton Court Forebay began, Italian Slough reverted back to its previous condition.

4.22 During the period that Italian Slough was used as the intake channel to the Delta Pumping Plant, channel configurations were measured to determine if scour damage was occurring (23). Monthly measurements were made of crosssectional areas at ten stations along the Slough from April 1968 to November 1969 by sonic sounding devices mounted in a boat. During this period DWR experimented with flows in Italian Slough greater than the design capacity of 59.5m3/s (2,100 cfs). These experiments were supplemented by velocity data and a tidal cycle measurement to determine maximum safe pumping rates at which there would be no scour. Pumping rates exceeded the design capacity a total of 153 days with a maximum daily rate of 88.5m3/s (3,124 cfs).

4.23 Comparison of first and last measurements showed a wide variation of changes in cross-sectional areas at the stations, from +3.8 percent (scour) to -3.9 percent (siltation). There were negligible changes at some stations. Thus, movement of material was indicated; however, there was not a prevailing trend of either scour or silting. This finding was partially supported by a one-day sampling of suspended sediment by the U.S. Geological Survey at each end of the Slough, which indicated no significant removal of material at a pumping rate of 1767 cfs.

Water levels and navigation:

4.24 As mentioned, SWP and CVP diversions lower water levels near the intakes. Water elevations in the South Delta channels are normally controlled primarily by tidal conditions even with the exports. High runoff flows to this section of the Delta have been largely restricted by upstream water development on the San Joaquin River. Except during extreme flood flows, Sacramento and San Joaquin River flows have a relatively minor effect on water levels in the South Delta when compared to the effect of Pacific Ocean tidal fluctuation.

4.25 The extent of lowered water levels caused by project operations has been determined by a series of tests conducted by DWR between 1968 and 1974. The tests indicated that all effects on water levels rapidly diminish with distance from the pumps, and that at a distance of 16 kilometers (10 miles) the effects were negligible.

4.26 The tests and later model studies have shown that continuous pumping by the CVP at 4,600 cfs lowers water levels by an average of 0.33 feet at Clifton Court Ferry, immediately adjacent to the export operations. The incremental drawdowns attributable to SWP diversions into Clifton Court Forebay are more complex, since the diversion rates change constantly with gate openings and head differentials, and because the gates are closed before, during, and after low-low tides. For this report, DWR made a hydrodynamic computer model study with varying diversion rates during a 24-hour period, with the gates closed 2 hours before low-low tide and opened one hour aftger. The diversion rates used were taken from an hourly operation study of Clifton Court Forebay during January of the wet year. This study showed the second highest average monthly diversion rate (6,143 cfs). Figure 12 shows the diversion rates used and the resulting water levels, as well as water levels with only CVP pumping. As indicated, the low-low drawdown attributable to SWP diversion is 0.35 feet. This is considered representative of maximum drawdown effects, based upon monthly, daily, and hourly diversion rates determined in the Forebay operation study. During the summer, drawdowns caused by SWP operations would be less. Average annual low tide drawdowns would be about 0.50 feet for federal and State diversions and 0.20 feet for State diversions only.

4.27 Such drawdowns do no affect any known use of the nearby channels. The minimum depths in the main navigation channels nearby are about 9 feet, measured at 0.0 USGS Datum. The largest motor boats using the nearby marinas have a draft of 3 to 4 feet. However, sailboats having slightly deeper drafts occasionally visit the marinas.

Several low water complaints have been investigated. Unusually low Pacific Ocean tides were found to be the cause of low water problems.

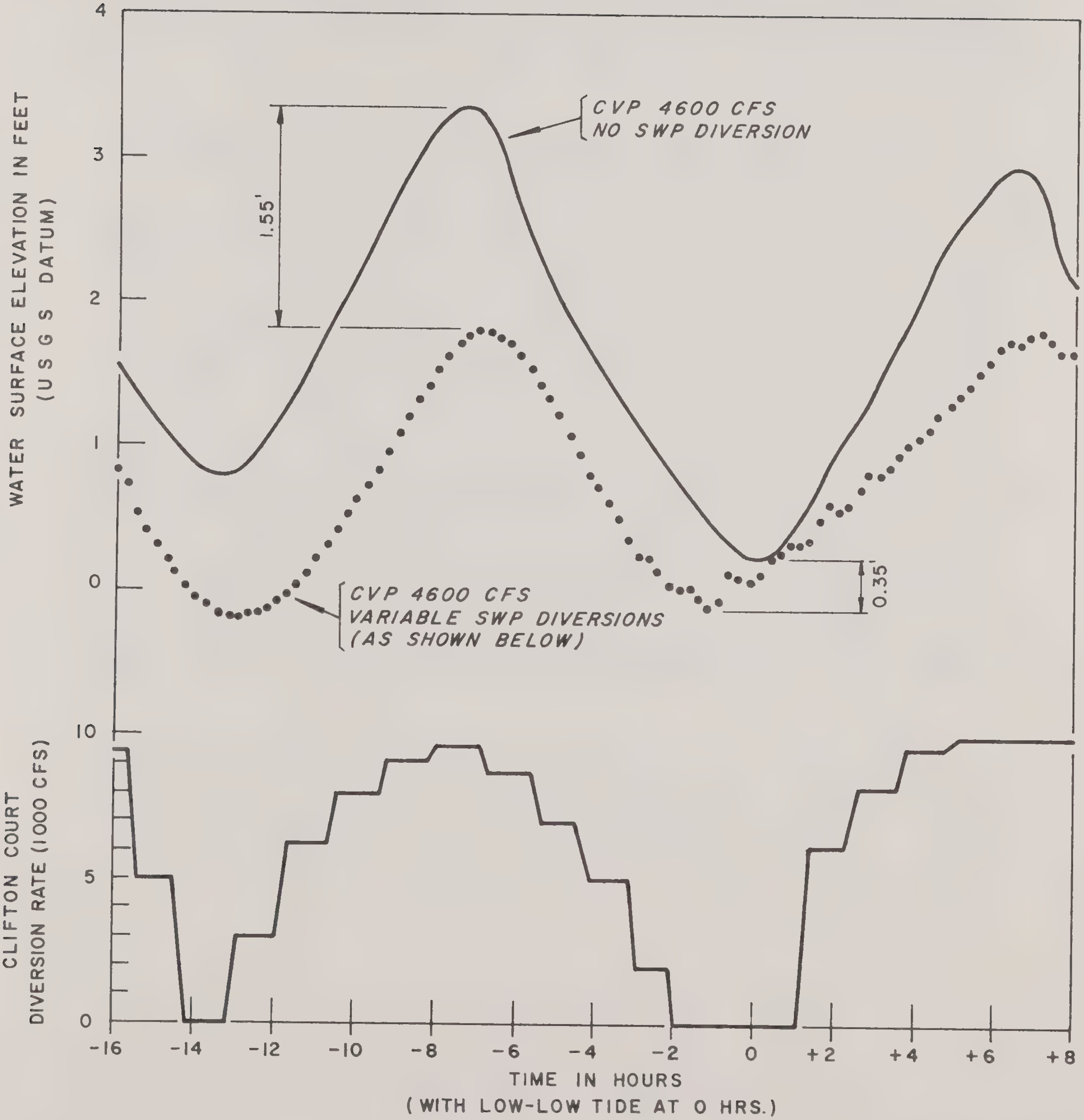


Figure 12 SWP DIVERSIONS AND EFFECTS ON WATER LEVELS, OLD RIVER AT CLIFTON COURT FERRY

Fisheries Impacts.

4.28 Striped Bass: The principal element upon which the impact of the Delta Pumping Plant on striped bass is estimated is the relationship between the number of young striped bass averaging 1.5 inches long and flow conditions in the estuary during May, June, and July. Substantial evidence suggests that survival at this size determines the number of bass surviving to become adults, so basing project evaluation on this relationship is the most reasonable approach.

4.29 The relationship indicates that diversions from the Delta and outflow control the survival of young bass. Diversions remove significant numbers of young bass for about four months during and after the spawning season. Also, high flow velocities in the Delta water transport channels reduce the striped bass food supply. Outflow determines the suitability of the lower San Joaquin River for spawning and also affects survival of the young bass after they hatch. The latter effect probably occurs because: (1) when outflow is high, bass eggs and young are transported downstream away from the diversions; and (2) high flows increase the capacity of the estuary to support bass by increasing the area over which eggs and young are dispersed, thus increasing available habitat.

4.30 Young striped bass survival in the Delta (east of Collinsville) can be predicted quite well from a statistical relationship between annual abundance in the Delta and (1) mean May-June diversions from the Delta and (2) mean May-June outflow. Survival in Suisun Bay (west of Collinsville) can be predicted well from a relationship between annual abundance in that area and mean June-July outflow. The estimated impact of the project is based on the sum of the predictions of survival in these two areas, using the above relationships for the designated years and also the SWP years (1968-1977).

4.31 Striped bass abundance indices at an average length of 1.5 inches are estimated to be lower with the Pumping Plant than without it (Table 3). Survival with the Pumping Plant is reduced 31% in the designated critical year, 15% in the above normal year, and 18% in the wet year. From 1968 to 1977, mean survival of young bass would have averaged about 23% lower with its Pumping Plant than without it.

TABLE 3
ESTIMATED INDICES OF ABUNDANCE OF STRIPED BASS
(WHEN MEAN LENGTH IS 1.5 INCHES)

Year Type	Without Pumping Plant			With Pumping Plant			% Reduction Due to Pumping Plant
	Delta	Suisun Bay	Total	Delta	Suisun Bay	Total	
Critically Dry (1934)	41	29	70	32	16	48	31%
Above Normal (1946)	52	52	104	40	48	88	15%
Wet (1967)	37	98	135	17	94	111	18%

4.32 Striped bass spawning is affected by salinity. In the past most spawning has occurred at salinities less than 200 mg/l TDS, although laboratory experiments suggest egg survival does not decrease until salinity exceeds 1,000 mg/l TDS. With the Pumping Plant projected salinities at Antioch, near the downstream end of the striped bass spawning area in the San Joaquin River, are substantially higher than without the Pumping Plant in all except the wet year (Table 4). With the Pumping Plant salinities in the above normal year are somewhat higher than the salinities at which striped bass normally spawn, but they are not excessive without the Pumping Plant. In the critical year salinities exceed normal spawning levels both with and without the Pumping Plant. However, with the Plant, salinity greatly exceeds the level that is known to cause egg mortality in the laboratory; whereas without the Plant salinities are slightly above that level in May.

TABLE 4
ESTIMATED MEAN MONTHLY SALINITY IN THE
WESTERN DELTA (ANTIOCH) DURING THE STRIPED BASS
SPAWNING SEASON (APRIL AND MAY)
(in ppm TDS)

Year	Month	Without Pumping Plant	With SWP Pumping Plant
Critical	April	854	3,155
(1934)	May	1,558	3,901
Above Normal (1946)	April	123	409
Wet (1967)	April	79	79
	May	77	77

4.33 The long term effect of higher salinities caused by the Pumping Plant is uncertain. Undoubtedly, in all years, varying amounts of suitable spawning habitat would still exist upstream in the San Joaquin River between the areas of high land-derived salinities and high ocean-derived salinities. Also, striped bass have a pronounced tendency to return to the same spawning area each year and, thus, might respond little to occasional less than optimal salinity conditions. However, regular occurrence of the same salinities could reduce spawning in the area gradually due to accumulative effects of either small differences in egg and larva survival or migratory preferences. A reduction in spawning in the San Joaquin River may have occurred due to increased salinity intrusion in the last 25 years. Catches of tagged bass in the San Joaquin River suggest that bass catch has declined substantially during this period (Table 5).

TABLE 5
PERCENTAGES OF SPRING (MARCH-MAY) STRIPED BASS
TAG RETURNS FROM THE SAN JOAQUIN DELTA AND
SACRAMENTO RIVER

Study Years	Area		Ratio Delta River
	San Joaquin Delta	Sacramento River Upstream from Courtland	
1950-52	62.4	8.3	7.52
1958-61	24.0	41.8	0.57
1965-66	24.4	28.9	0.84
1969-73	9.0	23.7	0.38

4.34 Adult bass migrations may also be affected by increased cross Delta transport of water caused by the Delta Pumping Plant. This effect is poorly defined because little is known about mechanisms controlling migrations. The problem is basically related to the degree to which adult bass depend upon the direction of flow for guidance. It seems reasonable to assume that water movement is one mechanism aiding fish navigation. During past operations of the SWP Pumping Plant, some bass apparently have followed the water toward the Pumping Plant and became effectively trapped in front of the fish screens. About 100-150 dead adult bass were removed from trash racks at the screens each year. Increasing exports could cause greater numbers of bass to arrive at the Pumping Plant and become trapped.

4.35 With Pumping Plant operation, increased water velocities in the transport channels could reduce the survival not only of young-of-the-year striped bass, but also survival and growth of one and two year old juveniles inhabiting the Delta. Juvenile bass feed both on benthic invertebrates and small fishes, such as threadfin shad. Both these food resources decrease in abundance as net channel velocities increase. If juvenile bass mortality continues due to water export pumping after the young-of-th-year index is established, the fishery would be depressed even more than suggested by the relationship between young-of-the-year survival and flow conditions in the estuary.

4.36 Mitigation measures for the effect of the SWP Pumping Plant on striped bass can be achieved through: (1) reduction of water exports during the period when diversions affect survival of young, or (2) increased outflows during that period. Both of these methods are utilized in the draft Four Agency Fish Agreement, as incorporated in the SWRCB's new Basin Plan and D-1485. However, the degree of

mitigation being sought by the Department of Fish and Game will not be realized.

King Salmon:

It is only possible to make a qualitative assessment of the SWP Pumping Plant's effects on king salmon populations of the Sacramento and San Joaquin Rivers. To make this assessment, of flow conditions in the Delta with and without the Pumping Plant were compared for the three selected years.

4.37 Sacramento River runs (upstream migrants): Conditions in the Sacramento River for adult salmon differ little with or without the Pumping Plant. Flows above Walnut Grove are the same and decrease only slightly below there with the Pumping Plant. Temperature and dissolved oxygen levels in the Sacramento River are probably unchanged by the Pumping Plant. Therefore, the migration of salmon in the Sacramento River would be little affected.

4.38 However, while the impact on the population cannot be quantified, the Pumping Plant probably causes a small reduction in the number of adult salmon that spawn in the Sacramento River. The Pumping Plant increases the amount of Sacramento River water in the San Joaquin Delta and produces reverse flows in the lower San Joaquin River during the period when salmon are migrating through the Delta. This results in increased straying, and accompanying delay, of adult king salmon bound for the Sacramento River and its tributaries. Such delay in reaching the spawning grounds probably causes some fish to die before they spawn.

4.39 Sacramento River runs (downstream migrants): As for upstream migrant adults, conditions in the Sacramento River for downstream migrant juveniles are probably little changed by the SWP Pumping Plant. However, flows from the Sacramento River through the Delta Cross Channel and Georgiana Slough increase slightly with the Pumping Plant and reverse flows toward the San Joaquin River through Three Mile Slough and Broad Slough increase substantially in all years. This increases the movement of Sacramento River downstream migrants into the San Joaquin Delta. Results from recent mark-recapture studies suggest such displacement from normal migration routes causes slower migrations and increased mortality of juvenile salmon while they are in the Delta. Whether or not faster traveling migrants suffer higher mortality downstream is unknown. Hence, while total effects of reduced migration rates in the Delta cannot be specifically defined, the identifiable effects are definitely detrimental.

4.40 More downstream migrant Sacramento River salmon are drawn to the fish screens with the Delta Pumping Plant in operation since the number arriving at the screens is a function of winter flows in the Secramento System and export rates during migration. The screens are

about 65-90% efficient for juvenile salmon and an unknown fraction of those salvaged also are lost in handling. However, the number of young salmon salvaged at the SWP and CVP screens probably represents less than 5% of the total outmigration, so present losses due to handling at the fish facilities do not exceed that percentage.

4.41 San Joaquin River runs (upstream migrants): The major impediment to migrant adult San Joaquin River salmon is the area of low dissolved oxygen and high temperature that develops near Stockton in most autumns. The SWP Pumping Plant aggravates this situation by further reducing or reversing flows in this area, allowing a buildup of organic material and depression of dissolved oxygen levels. The delay caused by the dissolved oxygen block interferes with successful spawning.

4.42 Flow rates needed to optimize the upstream migration are uncertain, but it is known that salmon migrate successfully past Stockton on the San Joaquin River at flows of 500 cfs. Except for October of the wet year evaluated, flows there are below 500 cfs in October and November of all years with or without the Pumping Plant. However, with the Pumping Plant flows during October and November of all three of the designated years were reduced an average of 82% below flows without the Pumping Plant. This likely has a detrimental effect on the upstream migration.

4.43 Migrating salmon use the "smell" of the water from their home stream to orient themselves. The Pumping Plant reduces the amount of San Joaquin River water in the Delta and increases the amount of Sacramento River water. The proportion of San Joaquin water is low even without the Pumping Plant, so the Plant undoubtedly aggravates an already undesirable situation with respect to orientation of upstream migrant salmon in the San Joaquin River.

4.44 San Joaquin River runs (downstream migrants): With or without the SWP Pumping Plant, conditions in the Delta are unfavorable for downstream migrant San Joaquin River salmon. Reverse flows that occur due to CVP pumping will occur more often and be of greater magnitude with SWP pumping, making flow oriented migration to the ocean more difficult.

4.45 Many young salmon migrating down the San Joaquin River are diverted to the SWP and CVP Pumping Plants through Old River. The proportion of the San Joaquin River flow diverted through Old River in the spring, and hence, the number of juvenile salmon, increases only slightly with the SWP Pumping Plant operating. The greatest change is in the critical water year, when the percent diverted into Old River increases from 92% without the State Pumping Plant to 101% with it. Hence, flows will reverse in the San Joaquin below the upper end of Old River producing an additional adverse impact on the salmon migration in this area.

4.46 Survival of downstream migrant juveniles, both from the Sacramento and San Joaquin Rivers, also may be affected by the availability of food. Juvenile king salmon are opportunistic feeders, utilizing primarily insects, but capable of shifting to other food sources such as Neomysis, Corophium, and Daphnia. In some parts of the Delta, the Pumping Plant may reduce the abundance of the latter food items, due to increased flow velocities in the channels.

4.47 Mitigation for some of the adverse impacts of the SWP Pumping Plant may be possible. Efficient fish screens and better handling and transportation at the Pumping Plant might reduce direct losses, although these are only a small part of total outmigration. The Delta Cross Channel should be open during adult migrations to facilitate passage of Sacramento River fish that migrate upstream through the Mokelumne system. Closing the Cross Channel gates during the spring would reduce the displacement of Sacramento River juveniles toward the San Joaquin River. Continued placement of a rock barrier at the mouth of Old River to increase flows in the San Joaquin each fall will help alleviate low dissolved oxygen conditions which block upstream migrations. The 1978 Water Quality Control Plan calls for gate closure during the spring. It also sets forth operating standards for the State and Federal Fish Protective Facilities.

Steelhead:

4.48 Steelhead are similar to salmon in many ways and their migrations through the Delta are subject to the effects of the SWP Pumping Plant. Migrations are limited to shorter periods than salmon however, and essentially no steelhead migrate to the San Joaquin River.

4.49 Steelhead migrate upstream through the Delta to the upper Sacramento River in early fall and presumably orient to the river flows similarly to salmon. Therefore, most steelhead migrate through the lower Sacramento River, but some are likely to move through the San Joaquin Delta and up the Mokelumne system to the Sacramento River. The effect of the Pumping Plant should be similar to that for Sacramento River salmon, although, since some steelhead survive spawning, delays in migration may not be as critical as with salmon.

4.50 Juvenile steelhead, and those adults which survive spawning, migrate downstream in the spring. They are subject to the same impacts of the Pumping Plant as juvenile Sacramento River salmon.

4.51 Few steelhead are collected at the CVP and SWP fish screens presently. Therefore, direct losses of juvenile steelhead at the SWP Pumping Plant fish screens are of minor significance.

American Shad:

4.52 Only a qualitative evaluation of the SWP Pumping Plant impact on the American shad population is possible.

4.53 Annual production of young shad depends on river flows in the spawning areas. Flows in the spawning areas are the same with or without the SWP Pumping Plant, so the Pumping Plant does not affect the initial production of young shad. However, there are two possible ways in which the Pumping Plant can affect American shad: (1) changes in food supply for young and adults, and (2) loss of young shad at the SWP fish screens.

4.54 The food supply of American shad migrating throughthe Delta is affected by the Pumping Plant. Adult shad in the Delta feed principally on Neomysis, but they also eat smaller zooplankton (copepods and cladocerans). Young shad feed primarily on copepods and cladocerans. Neomysis populations in the central Delta probably are reduced by the Pumping Plant (see Invertebrates section). Small zooplankton are most numerous in the Delta in areas of low flows (low net velocities). Flows in the lower Sacramento River are similar with or without the Pumping Plant in critical (1934), above normal (1946), and wet (1967) years. With the Pumping Plant, flows are lower in the San Joaquin River below the mouth of the Mokelumne and are higher in Old and Middle Rivers. Thus, the effect on food supplies of young shad is variable, depending on location, and the overall impact is uncertain. The food supply of adult shad is probably reduced, but the impact of this on adult survival or spawning success is not known.

4.55 Many young shad are drawn to the Delta Pumping Plant and salvaged at the fish screen. Between 1972 and 1977 from 338,000 to 4,288,000 young shad were captured annually at the SWP and CVP fish screens combined. About 60% of these fish were taken at the SWP screens. This suggests that operation of the SWP Pumping Plant caused a substantial increase in the number of young American shad drawn to the fish screens.

4.56 The number of shad actually reaching the screens is at least 25% greater than the above numbers, considering those fish not screened successfully. Also, mortality of the shad captured is probably quite high since shad are difficult to handle and transport. Limited experiments indicate a 28% mortality just from holding in the tanks at the Delta facility for 1-4 hours. Other shad probably are drawn from their normal migration paths, but do not reach the fish screens. The fate of those fish is unknown.

4.57 Hence, while the number of downstream migrant juvenile shad dying as a result of water export pumping is unknown, the rather large numbers of shad drawn to the screens, the probable high mortality of those fish, and the fact that other shad probably are drawn from their normal migration routes suggests that losses due to export pumping reduce shad survival.

Sturgeon:

4.58 Two species of sturgeon, white and green, live in the estuary. The white sturgeon is the most abundant. More information is available about white than green sturgeon, so the analysis of the impact on the SWP Pumping Plant on sturgeon is based on that information. The two species are probably similar in their environmental requirements in the Delta. Factors controlling white sturgeon populations are poorly understood, therefore the evaluation of project effects is mostly qualitative.

4.59 Sturgeon spawn primarily in the Sacramento River upstream from the Delta; a few may spawn in the San Joaquin River. Conditions in the spawning areas are unchanged by the Pumping Plant, so spawning is not affected.

4.60 Many larval sturgeon reach the Delta in years of high river flows, but they are scarce there in years of low runoff. Larvae and post-larvae are poor swimmers and should be readily subject to diversion. Few young sturgeon are salvaged at the fish screens at the Pumping Plant, but sturgeon are bottom dwellers like catfish, and the screens are known not to be effective on catfish so many of the sturgeon arriving at the screens may pass through rather than being salvaged.

4.61 Young sturgeon in the estuary depend on adequate populations of *Neomysis* and *Corophium* for food. The probable decrease in *Neomysis* abundance in the central Delta with the Pumping Plant (see Invertebrate section) may adversely affect young sturgeon survival and/or growth. *Corophium* populations probably also change due to water export pumping, either increasing or decreasing depending on location. The lack of knowledge concerning distribution of young sturgeon in the estuary makes it impossible to predict the overall effect of changes in the food supply.

4.62 Preliminary analysis suggests a relationship between white sturgeon year class strength, spawning stock size, and the percentage of May and June inflow that is exported. If this is truly a cause and effect relationship and the spawning stock index is 45 units (equivalent to the mean from 1947 to 1970), the above relationship suggests that exports by the SWP Pumping Plant reduce white sturgeon year class abundance by 17% in critical (1934), 15% in above normal (1946), and 7% in wet (1967) years. The cumulative effect of these reductions on subsequent spawning stock size could seriously depress the sturgeon population.

Resident Game Fishes:

4.63 Factors controlling resident game fish populations in the Sacramento-San Joaquin Delta are not well understood, but their requirements related to water development are generally less demanding than those of anadromous species. Effects of the SWP Pumping Plant on resident game fishes can only be assessed qualitatively.

4.64 Four species of catfish and three species of the sunfish family are the principal resident game fishes of the Delta. The catfish species are the white and channel catfishes, and black and brown bullheads. The most important sunfishes are the black crappie, largemouth bass, and bluegill.

4.65 The various species of catfish have quite different distribution patterns in the Delta. These differences are attributable to net flow velocities. The white catfish is the most versatile and abundant. Black and brown bullheads are rarely found anywhere other than in the quiet waters of the dead-end sloughs. Channel catfish prefer the swift water of the river channels upstream from the central Delta.

4.66 The Pumping Plant impacts catfish populations by altering flow patterns which determine net channel velocities. Flows have other effects too. They influence salinity levels and abundance of food organisms. Catfish are also subject to direct removal from the Delta by project diversions.

4.67 The Pumping Plant generally increases flows in the water transport channels of the central and south Delta. This is probably detrimental to white catfish which prefer lower velocities, but has little effect on bullheads which would find velocities in the channels too high even without the Pumping Plant. Increased flows due to the Pumping Plant do not increase net velocities enough to widen the distribution of channel catfish in the Delta.

4.68 Corophium and Neomysis are the major foods of catfish in the Delta. Populations of these invertebrates generally decrease in those channels where flows increase due to the Pumping Plant (see Invertebrates section). These decreases may reduce catfish growth and survival.

4.69 Habitat preferences of the different catfish species influence their susceptibility to direct removal at the diversion site. Bullheads prefer quiet water. Channel catfish are primarily upstream from the Delta. Hence, the young of these species are relatively immune to losses at the export pumps.

4.70 White catfish are more widely distributed and many young-of-the-year are drawn to the Pumping Plant. Most of these are carried into the export canal with the water since they do not respond

well to the fish screen. Hence, many white catfish are lost from the Delta due to water exports by the Pumping Plant.

4.71 Salinity tolerances of catfish are not precisely defined. White catfish have been taken in Suisun Bay at salinities up to 5,800 mg/l TDS. White catfish and bullhead numbers begin to decline in small sloughs of the Suisun Marsh at salinities above about 5,000 mg/l TDS. Between 5,000 and 10,000 mg/l they concentrate in the areas of lowest salinity in the marsh. White catfish are rare and bullheads are absent there above about 10,000 mg/l TDS. All resident catfishes are most abundant where TDS levels are less than 1,000 mg/l. Maximum salinity at Chipps Island in the critical year (1934) without the Pumping Plant is about 6,000 mg/l TDS; with the Pumping Plant it is 8,000 mg/l. In the above normal year (1946) these values are 4,000 mg/l and 6,000 mg/l, respectively. In the wet year (1967) they are 1,000 mg/l and 3,000 mg/l. This suggests that the Pumping Plant restricts the distribution of catfish in the extreme western Delta during some months of all three year types. High salinities are more persistent in a critical year, so the impact is probably greatest then.

4.72 Black crappie, bluegill, and largemouth bass are the most sought after species of sunfishes in the Delta. They prefer quiet water and sluggish streams. In the Delta they are most abundant in the dead-end sloughs.

4.73 Because of their habitat preferences, sunfishes are little affected by the Pumping Plant. Without the Pumping Plant flows probably would not be low enough in the water transport channels to be acceptable to sunfishes. Decreases in the food supply (Neomysis, Corophium, and crustacean zooplankton) in the main channels due to increased flows with the Pumping Plant are detrimental only to the small populations of sunfishes utilizing these areas.

4.74 Few sunfishes are salvaged at the SWP fish screen since their habitat preference makes them relatively invulnerable to diversion. Therefore, the Pumping Plant causes little direct loss of sunfishes.

4.75 Sunfishes are most abundant at salinities below 1,000 mg/l TDS. Since little suitable habitat exists for sunfishes in the western Delta, salinity increases there with the Pumping Plant will not substantially affect sunfish distribution.

Resident Nongame Fishes:

4.76 In addition to fishes which are harvested by anglers and commercial fishermen, a variety of other fishes occur in the Sacramento-San Joaquin Delta. Some are important forage for game fish, while others prey on game fish or compete with them in a variety of ways.

4.77 Three native minnows (the Sacramento squawfish, Sacramento hitch, and Sacramento blackfish) and three introduced minnows (carp, goldfish,

and golden shiner) are basically freshwater species. Factors affecting their abundance have not been well defined. Except for squawfish, which are found primarily upstream from the Delta, these minnows tend to be most numerous in areas where flow velocities are low. Few are found west of Antioch. Increased salinity encroachment in the western Delta and increased flow velocities in cross Delta transport channels due to the SWP Pumping Plant probably restrict and degrade their habitat to an unknown extent.

4.78 Splittails, another native minnow, are found few places other than in the Sacramento-San Joaquin Estuary. They have a higher salinity tolerance than the other minnows and likely are less affected by the increased salinity intrusion in the western Delta caused by the Pumping Plant. Splittails spawn, at least in part, in quiet waters along the eastern periphery of the Delta. The Pumping Plant has had no known impact on spawning success.

4.79 The threadfin shad is an important forage fish. It is most numerous in slow moving waters around the eastern edge of the Delta, but some also occur downstream in the bay area. Increased cross Delta flows due to the Pumping Plant probably have a small negative impact on this species. Large numbers of threadfin shad are salvaged at the SWP fish screen and, like American shad, many salvaged fish probably die during handling and transport. Threadfin shad are prolific and short-lived, so the effect of those diversion losses on the population may be minor.

4.80 Delta smelt, longfin smelt, starry flounder, tule perch, and sculpins are found in the Delta and bays. They have reasonably wide salt tolerances, so moderately increased salinities caused by the Pumping Plant probably alter their range somewhat but have minimal effect on abundance.

4.81 Large numbers of adult delta smelt are captured at the SWP fish screen and many larvae undoubtedly pass through the screen. The impact on the delta smelt population of the higher losses with the Pumping Plant is unknown.

4.82 Annual production of longfin smelt may depend on river flow during the spawning season. There is a significant correlation between the number of smelt in the estuary in the fall and outflow past Chipps Island in April and May. Thus, production of longfin smelt may be controlled by factors similar to those that influence young striped bass survival. The relationship between smelt production and outflow suggests that the Pumping Plant, by reducing outflow, decreases smelt production by 10% in the critical year, 24% in the above normal year, and 22% in the wet year.

Impacts on Aquatic Invertebrates.

4.83 Invertebrate animals in the Delta are either zooplankton or zoobenthos. Neomysis is a form of zooplankton, but, because of its importance as a fish food, it is discussed under a separate heading.

Zooplankton (except Neomysis):

4.84 Crustacean plankton (copepods and cladocerans) are important fish food organisms. In the Delta freshwater crustaceans are dominant but during dry years the brackish water copepod, Eurytemora, becomes abundant in the western Delta. The abundance of freshwater plankton depends on oceanic salinity intrusion, phytoplankton abundance (chlorophyll a) and water residence time (net velocity). High crustacean abundance is associated with low oceanic salinity, high chlorophyll a and total dissolved solids (TDS) concentrations, and low net flow velocities. The SWP Pumping Plant affects zooplankton by altering all of these factors.

4.85 The relationship between plankton catches, net velocity, and TDS in 1963 was used to estimate the effect of the Pumping Plant on zooplankton abundance in the Delta. TDS levels were estimated from the relationships between flow and TDS in various channels. Zooplankton abundance then was estimated for several important Delta channels in three water year types for conditions with and without the Pumping Plant (Table 6). These values should be regarded as indices and are not precise; they are suggestive of trends with and without the Pumping Plant. The actual regulation of zooplankton populations is much more complex than implied by this method of estimation; however, the general pattern predicted seems reasonable.

TABLE 6
Predicted Mean Zooplankton Indices 1/
in Selected Years With and Without
the SWP Pumping Plant

	Critical Year (1934)		Above Normal Year (1946)		Wet Year (1967)	
	With Pumping Plant	Without Pumping Plant	With Pumping Plant	Without Pumping Plant	With Pumping Plant	Without Pumping Plant
San Joaquin River at San Andreas	54	48	49	40	22	9
Middle River at Bacon Island	36	46	28	44	35	42
Old River at Bacon Island	40	47	35	45	38	42
North Fork Mokelumne	32	33	25	26	23	23
South Fork Mokelumne at Terminus	28	28	27	27	27	27
Sacramento River at Rio Vista	10	10	2	2	0	0

1/ Primarily crustacean plankters. Values are means for the April to October period derived from mean predicted April to October flows and TDS levels predicted from the flows.

4.86 This analysis suggests that the Pumping Plant reduces zooplankton populations in the southern Delta water transport channels. The Pumping Plant changes flows only slightly in the Mokelumne system and in the lower Sacramento River, so zooplankton are little affected in these areas. The Pumping Plant increases zooplankton abundance in the San Joaquin River below the Mokelumne by reducing flow velocities there.

Zoobenthos:

4.87 Two amphipods, Corophium stimpsoni and Corophium spinicorne, are important constituents of the Delta's zoobenthos. They are the principal food for sturgeon, white and channel catfish, tule perch, and small black crappie in the Delta. They are also the second most important food item of young striped bass. Other abundant benthic organisms are the Asiatic clam, tendipedid larvae, oligochaete worms, and crayfishes. All are eaten by Delta fishes, but none are as important as Corophium as fish food.

4.88 The key factor in the production of zoobenthos in the Delta, especially <u>Corophium stimpsoni</u>, appears to be the type of substrate present. Shifting bottoms composed of medium to coarse sand are the least productive types. Those are associated with high net flow velocities, which suggests that the finer sediments are washed away.

4.89 Therefore, the effect of the Pumping Plant on zoobenthos in the Delta may be similar to that for zooplankton. In those channels where the Pumping Plant increases flows, benthic populations are probably depressed; where flows are decreased, populations may be higher.

4.90 Crayfish occur in most Delta channels. They are most abundant in the channels fed by the Sacramento River north of the San Joaquin River. Many of these channels have high flow velocities because they transport water toward the export pumps. Hence, high flow velocities caused by export pumping apparently have not been detrimental to crayfish. However, crayfish have a low salinity tolerance and increased salinity in the western Delta due to the Pumping Plant probably restricts crayfish distribution there.

Neomysis:

4.91 The opossum shrimp, <u>Neomysis mercedis</u>, is an important part of the food web of the Sacramento-San Joaquin Estuary. <u>Neomysis</u> eat detritus and phytoplankton and are in turn fed upon by fish, especially young striped bass. Changes in the <u>Neomysis</u> population due to an altered environment probably affect striped bass and other fishes, both in the Delta and in Suisun Bay.

4.92 The analysis of the effect of the SWP Pumping Plant on <u>Neomysis</u> must necessarily include Suisun Bay since over 60 percent of the population is normally found there. More than 90 percent of the total population is usually found in Suisun Bay and the western Delta.

4.93 The SWP Pumping Plant impacts the <u>Neomysis</u> population mainly by reducing Delta outflow. Average summer-fall <u>Neomysis</u> population indices for Suisun Bay and the western Delta combined are significantly correlated with outflow past Chipps Island and chlorophyll <u>a</u> concentration. Outflow determines the size of optimum <u>Neomysis</u> habitat and chlorophyll <u>a</u> is a measure of food availability. Chlorophyll <u>a</u> concentrations are affected by a complexity of interacting factors (see Phytoplankton section), and can therefore vary considerably at any given outflow.

Table 7 shows estimated <u>Neomysis</u> abundance for the three selected years with and without State pumping, and pertinent informatin about the estimates.

4.94 During the critical year it is estimated that the Pumping Plant reduces <u>Neomysis</u> abundance 21 to 81 percent, mainly because the low

flows are expected to be accompanied by very low chlorophyll a concentrations. At the higher flows without the Plant past observations suggest chlorophyll a will be much higher. In the above normal year, the Plant is predicted to cause a slight decrease (15-18%) in Neomysis abundance at each expected chlorophyll a level because the reduced outflow reduces Neomysis habitat. However, chlorophyll a could be higher or lower with the Plant than without it. In those cases Neomysis abundance could be as much as 27% greater (Compare the 4.5 index without the Plant to the 5.7 index with it.) or 33% less (5.5 vs 3.7) with the plant. In the wet year pumping could decrease Neomysis abundance 16 to 22% at each expected chlorophll c level. If chlorophyll hoped to be higher or lower with the plant operation, Neomysis abundance could increase 20% or decrease 51%.

TABLE 7
Estimated Neomysis Abundance Indices (X 10^{10}).1/

	Mean July-October Outflows2/ (cfs X 10 3)	Chlorophyll a (ug/l) 5	15	25	35	45
Critical (1934)						
With Pumping Plant	3.946	1.2				
Without Pumping Plant	6.520			3.8	4.8	5.8
Above Normal (1946)						
With Pumping Plant	6.108			3.7	4.7	5.7
Without Pumping Plant	9.478			4.5	5.5	6.5
Wet (1967)						
With Pumping Plant	11.741	3.0	4.0	5.1	6.1	
Without Pumping Plant	16.179		5.1	6.1		

1/ As calculated using multiple regression equation Y = - .3734 + .103X. + .242 X_2, where Y is Abundance Index (X10^{10}), X, is chlorophyll a concentration, and X_2 is outflow.

2/ Outflows from operation studies
3/ Concentrations observed at similar outflows from 1968 to 1967

4.95 Other factors that may influence Neomysis abundance in the Delta include high net flow velocities in the channels and removal of mysids from the Delta in the water that is exported. Neomysis abundance tends to decrease as net velocity increases. Few mysids occur in the central Delta water transport channels where net velocities are high. Also some mysids are pumped out of the Delta and are transported through the SWP and CVP canals to San Luis Reservoir. A thorough evaluation of such removal has not been possible as

Neomysis abundance was not monitored before significant amounts of water were exported from the Delta.

Fish Salvage Efficiency.

4.96 The overall fish salvage efficiency of the Delta complex depends upon several factors, including the efficiency of the fish screens and the effectiveness of the fish collection, hauling and release program. Clifton Court Forebay may also be a factor in the overall fish salvage efficiency.

4.97 Records collected at the State and Federal fish facilities show that 44 species of fish have been recorded during salvage operations. Striped bass are the most abundant December through March and June through August and either second or third in abundance the remaining months. Threadfin shad are the most abundant in September and October, American shad in November, Delta smelt in May and white catfish in April. In all months king salmon are the fifth or sixth most abundant. Striped bass, king salmon, American shad and white catfish are among the more desirable sport fish in the estuary, and threadfin shad and Delta smelt are important forage fish.

4.98 Data and procedures have been developed to estimate fish screen efficiencies for three species: striped bass, king salmon, and white catfish. Important factors are the monthly mean size and relative monthly abundance of each species and the velocities at the facility. The monthly mean sizes and relative abundance of each species are based on a 1973 report (12) and data collected at the facility between 1968 and 1975. Velocities, which vary with pumping rates, were are determined by operation studies.

4.99 Projected efficiencies assume the facility is operated to maximize efficiencies for the three species, given the pumping rates, and that all operating channels are open. At times, conflicts between species are apparent. The values presented are appropriate for comparisons between operational conditions, but should not be considered absolute. No estimation of actual numbers salvaged or lost has been attempted.

4.100 The portion of the fish salvage operation involving holding, transporting, and releasing the screen fish has never been evaluated in detail, although several small studies are in progress. Losses during these operations compound the impact on any species entrained. Some evidence indicates mortalities ranging from 4 to 34 percent for striped bass, 4 to 21 percent for white catfish, and 14 to 48 percent for American shad are attributable to collecting and holding, fish at the facility. Threadfin shad and pond smelt mortalities ranged from 0 to 20 percent and 49 to 100 percent respectively. Other preliminary results indicate that king salmon survival is reduced substantially when the fish are exposed to the holding tanks and collection systems. Since 1970, the number of king salmon salvaged, per acre-foot or water pumped, has differed at the State and Federal facilities. The major difference between facilities is the presence of Clifton Court Forebay.

4.101 A small scale study conducted in 1976 indicated that only 3 percent of king salmon released into the forebay were accounted for at the fish protective facility. Should these preliminary results be confirmed by planned future studies, the forebay will have to be considered as a major source of king salmon losses. The most probable explanation for these losses would be the presence of a resident predator population in the forebay.

4.102 Estimated annual efficiencies for the existing pumping plant and fish facility are shown below. These annual efficiencies are the sum of estimated monthly screen efficiencies times the monthly abundance factors.

	Species		
Year Classification	Striped Bass	King Salmon	White Catfish
Critically Dry	.64	.72	.62
Above Normal	.51	.78	.61
Wet	.45	.75	.60

Effects on Delta Flow Patterns.

4.103 It was previously mentioned that the CVP and SWP pumps cause flow reversals in some Delta channels during low streamflow periods, and that these flow reversals adversely affect water quality and fisheries.

4.104 Net flows in practically all Delta-Bay channels were estimated by DWR's hydrodynamic model. Six model runs were made for the three hydrologic conditions and the "with" and "without" Delta Pumping Plant conditions.

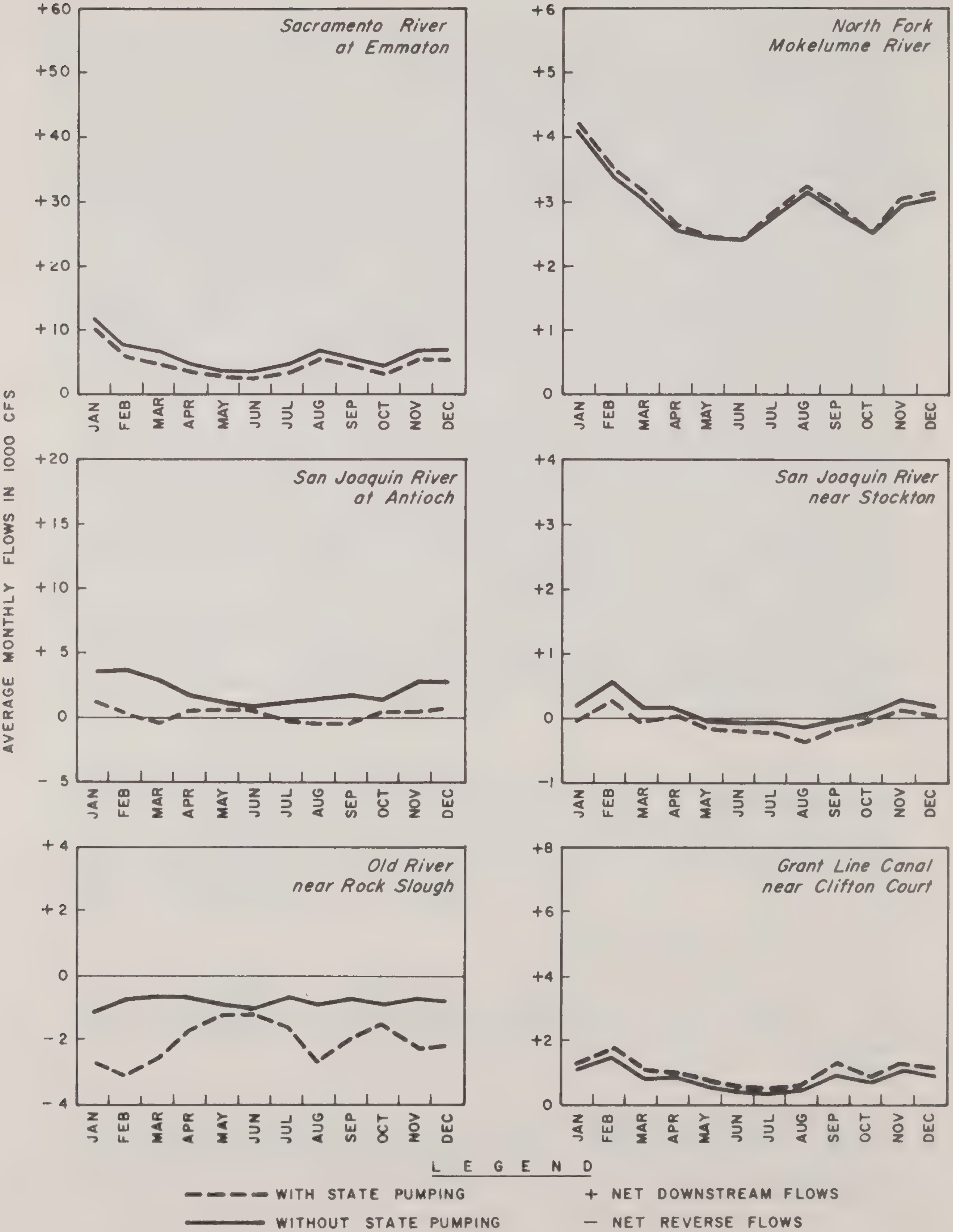


Figure 13a EFFECTS OF DELTA PUMPING PLANT ON FLOWS IN SELECTED CHANNELS, CRITICALLY DRY YEAR (1934)

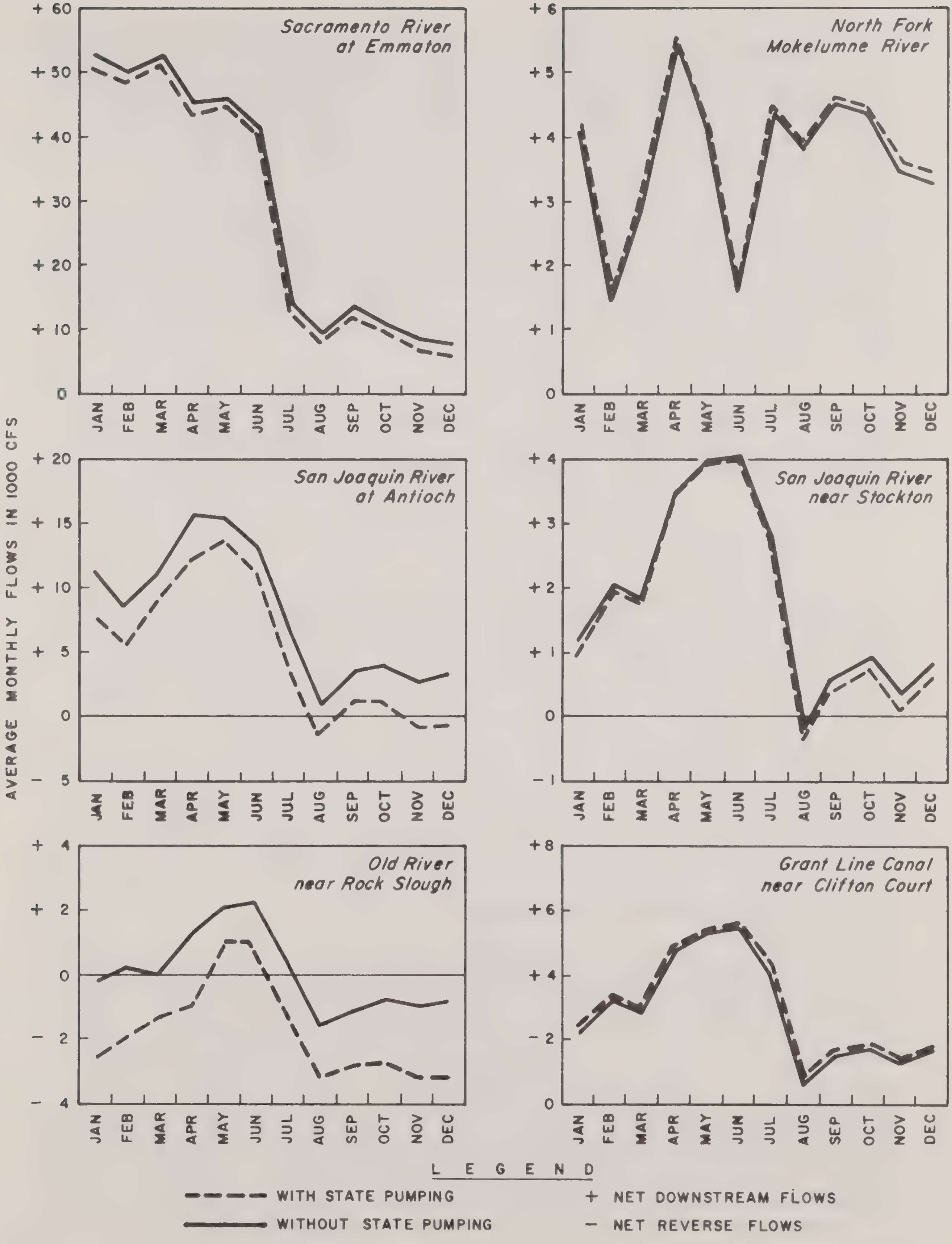


Figure 13b EFFECTS OF DELTA PUMPING PLANT ON FLOWS IN SELECTED CHANNELS, WET YEAR (1967)

4.105 Figures 13a and 13b compare resulting monthly net flows at six selected channels in the Delta which are considered indicative of the operational effects of the Delta plant on Delta flows. Flow reversals attributable to State pumping are shown as a change from a net downstream (positive) flow to a net reverse (negative) flow. Two of the channels (Sacramento River and North Fork Mokelumne River) are north of the San Joaquin River, where the effects are relatively minor. Along the San Joaquin River, the dominant effect is a reduction of net downstream flows, with flow reversals during months of low stream flows. In the channels north of Clifton Court, such as lower Old River and Middle River, the dominant effect is a significant increase in reverse flows. In the southern Delta channels, such as Grant Line Canal and upper Old River, the effect is to increase net downstream flows.

4.106 Under the proposed operation and with existing facilities, no permanent mitigation measures are possible for changed flow patterns and flow reversals. The temporary installation of barriers at carefully selected sites can achieve specific localized benefits. An example of this is the Old River closure to reduce the net flow reversal effects of SWP-CVP diversions during the fall salmon runs on the San Joaquin River.

4.107 Other than the Old River Closure, temporary installations in the Delta, are generally considered drought mitigative measures rather than mitigation measures for pumping effects. Such measures were an important aspect of SWP operations in 1976 and 1977 and deserve mention here as possible actions in future drought periods. Further information on drought mitigative facilities may be found in the DWR report, "The Continuing California Drought", (19).

4.108 The Peripheral Canal is the proposed permanent mitigation measure for flow reversals and related water quality and fishery effects of the pumping plants. A detailed discussion of its impacts is presented in the draft EIR for the Peripheral Canal.

Impacts on the movement of sediment.

4.109 Delta and Bay waters are normally turbid and contain significant amounts of fine material in suspension. The sediments originate in the Central Valley drainage basin, with the Sacramento River and its tributaries supplying an estimated 80 to 94 percent of the incoming sediment load. Daily measurements of suspended sediment concentrations collected at Sacramento since 1956 have ranged from 11 to 1,960 milligrams per liter (mg/l), while daily discharge has ranged from 200 to 525,000 tons. Other major sources of sediment are the San Joaquin River, the Yolo Bypass, and waste discharges. About 80 percent of the annual sediment inflows enter the Delta from November through April. There is a decreasing trend in annual sediment loads due to upstream water projects and other developments, 31/ and

possibly the fact that the Sacramento River is still undergoing alterations, of its regime as a result of hydraulic mining in the nineteenth century. Each year about 15 times the annual river-sediment discharge to the Estuary is resuspended by tidal flows, wave action, river inflows, watercraft turbulance, dredging, etc., and is redistributed within the estuary.

4.110 Within the Delta-Bay Estuary, the mechanics of sediment deposition movement, and discharge to the ocean are complex. The primary factors are: (1) river inflows, (2) tidal exchange, (3) the two-layered flow estuarine circulation, (4) surface wave action, (5) dredging, and (6) export pumping. Discussion of these mechanisms may be found in the Fifth Annual Report of the Interagency Ecological Study Program.13/ Further information is available in a recent report by U.S.B.R. One of the major objectives of the Ecological Studies program is to predict the effect of Federal and State diversions on productivity in the Estuary. Turbidity is related to concentrations of suspended matter, which absorb and scatter light rays. Concerns about the reduction of sediments in the Estuary by upstream projects and by exports were previously mentioned.

4.111 Measurements of suspended sediment entering the Delta Mendota Canal from September 1973 to September 1974 indicated that concentration varied directly with total Delta export and inversely with the solids concentration in the Sacramento River. It appears that there is deposition of sediment in the channels leading to the export facilities during the winter and that resuspension of the sediment occurs in the summer during periods of high export.

4.112 The best measure of the overall sedimentation impact of SWP diversions that can be made with present knowledge is to express sediment inflows to Clifton Court Forebay as a percentage of total sediment inflow to the Delta-Bay Estuary over a common time period. Application of the 1973-1974 concentrations entering the Delta Mendota Canal to monthly amounts pumped at the Delta Pumping Plant during this period gives a value of 140,000 tons of suspended solids diverted. This was about 3 percent of the measured suspended sediment inflow of the Sacramento and San Joaquin Rivers during the 1973-74 water year. A similar estimate was made for the 1980 level of operations during a wet year, which represented an 80 percent increase of annual pumping amounts. This estimate, based upon the relationships between sediment concentrations and total Delta exports during 1973-74, was 327,000 tons. This amount represents about 10 percent of the measured sediment inflow of the two rivers during 1967.

DWR has received complaints about scouring and deposition at several islands in the channels north of the Forebay, despite the precautions taken in seperating the Forebay, and is observing conditions at these sites.

In September 1973, the USBR conducted sampling at Clifton Court Forebay, the discharge headworks of the Delta Pumping Plant, and at the control structure regulating outflow from Bethany Reservoir. During the sampling period, the pumping rate averaged 979 cfs. The suspended solid load entering Clifton Court averaged 49 mg/l or 130 tons per day. The sediment load was found to have decreased to 45 tons per day at the pumping plant discharge (indicating a trap efficiency of 65 percent in the forebay) and further reduced in Bethany Reservoir to 38 tons per day. Thus, most of the sediment from Delta waters is deposited in the northernmost reaches of the aqueduct system. Sediment deposition has not been a major operational problem in the aqueduct.

4.113 Since accurate surveys of the ground surface were not made prior to filling of Clifton court, previous total sediment deposition rates cannot be determined. Based on the USBR data, the present average annual decrease in Forebay capacity has been estimated at 97 acre-feet.[31] A survey of the Forebay bottom made in 1977 will provide the basis for future determinations of deposition rates.

4.115 Water quality effects.

Salinities: A study of the salinity effects of the Delta Pumping Plant was conducted using mathematical salinity models of the Estuary. One model computes chloride concentrations due to salinity intrusion from the ocean, and another computes TDS concentrations due to land-derived salinity from the river inflows and agricultural drains.

4.115 The salinity models were used to demonstrate the effect of the Delta Pumping Plant on salinity distributions in the Bay and Delta, and to verify that the estimated flows would satisfy the water quality standards (1975 Basin Pland and Four Agency Fish Agreement). Figure 14 (a, b, and c) present graphs of computed salinity for 6 selected stations. The appropriate salinity standards are also shown for applicable stations.

4.116 As expected, the graphs generally indicate higher concentrations for the "with State pumping" than the "without State pumping" conditions, however, all salinity projections satisfy the stated water quality standards.

4.117 Phytoplankton and Ressolved Oxygen: Delta Pumping Plant operations were assessed in terms of their projected impacts on phytoplankton levels and dissolved oxygen concentrations in the Sacramento-San Joaquin Delta and the adjacent Suisun Bay region. Two mathematical models were used in the analyses. In the Delta proper, extending from Sacramento and Mossdale to the western limit of the Delta, a steady-state model was employed to project summer average water quality conditions. In the Western Delta-Suisun Bay region,

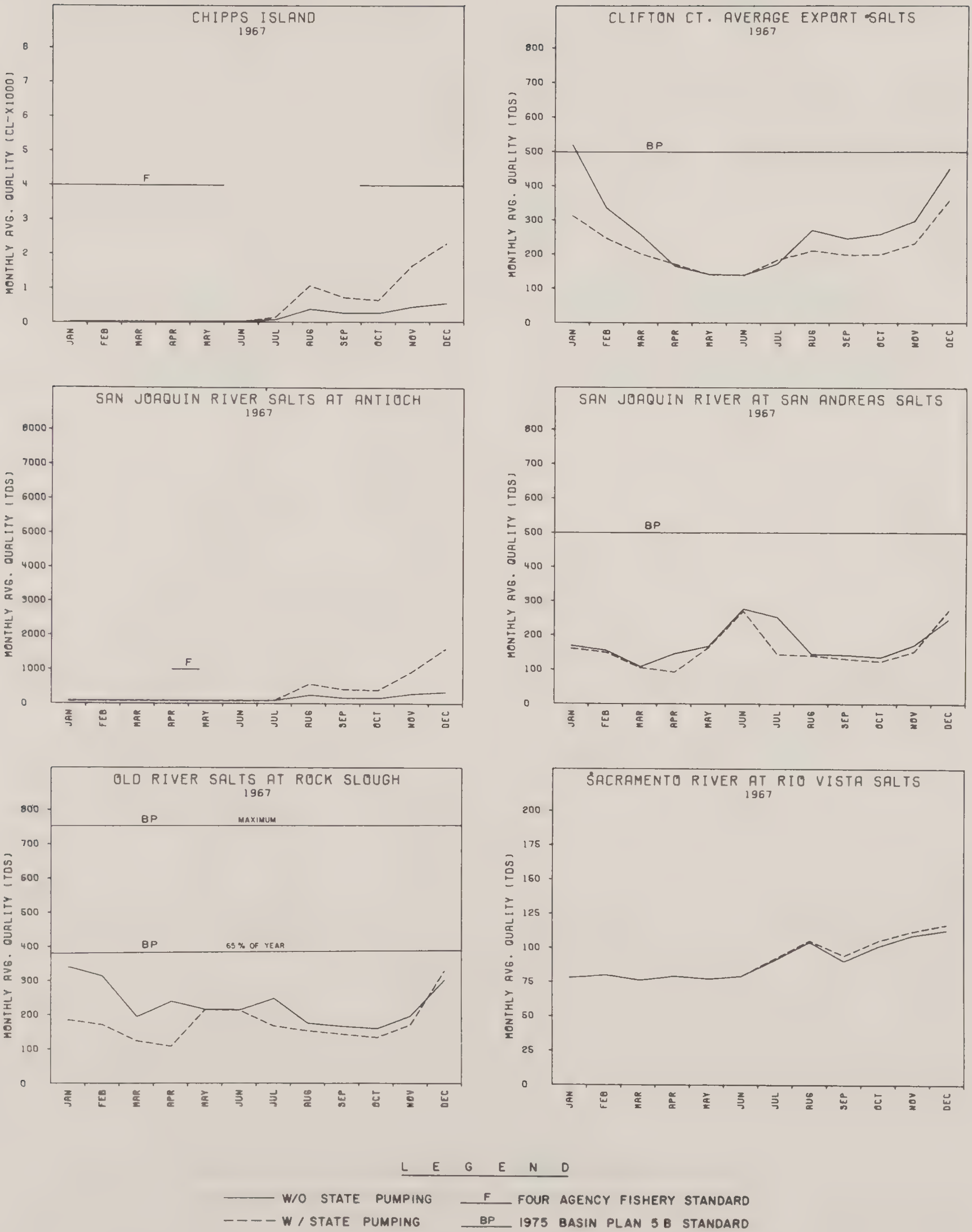


Figure 14a PROJECTED SALINITIES, WET YEAR (1967)

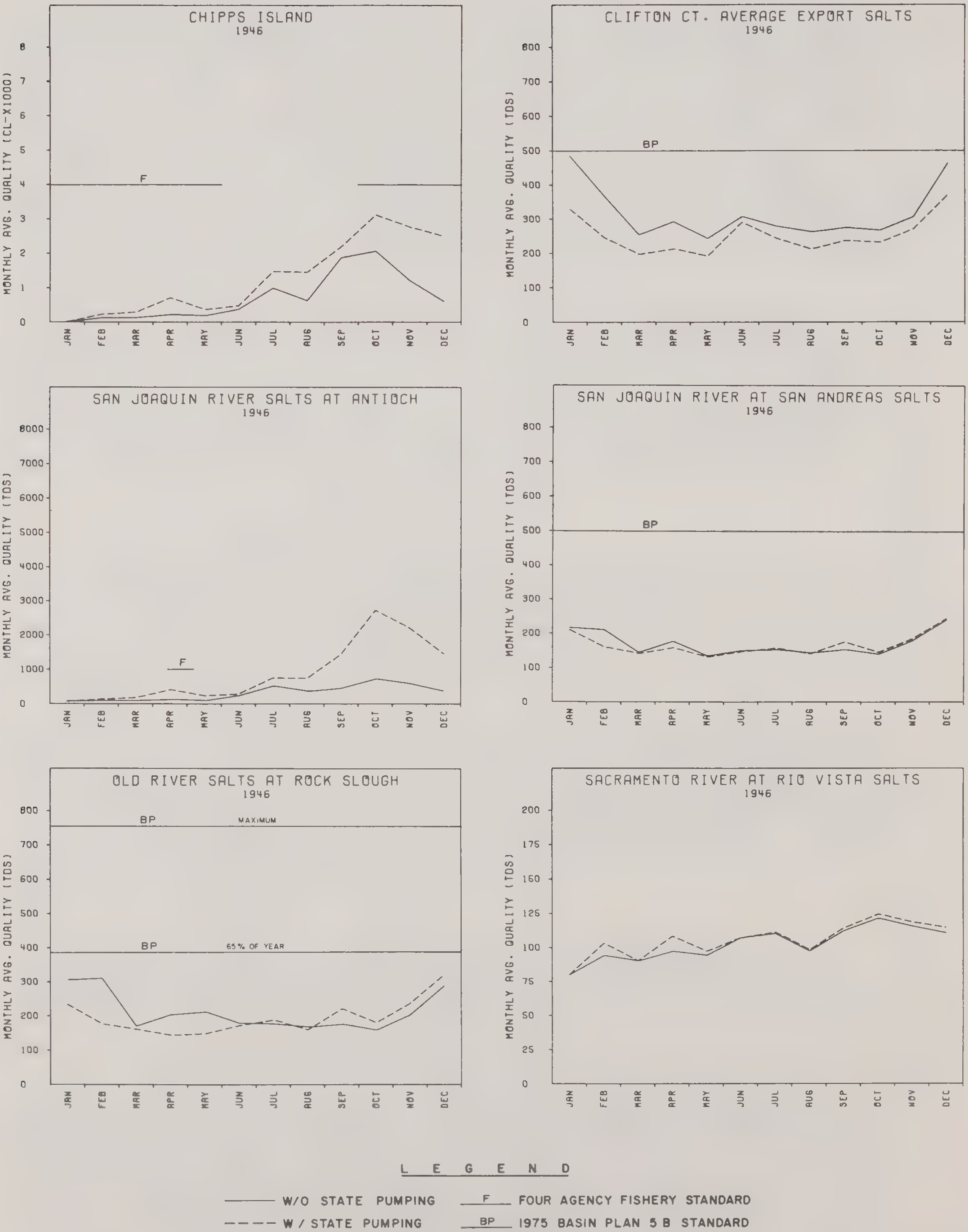


Figure 14b PROJECTED SALINITIES, ABOVE NORMAL YEAR (1946)

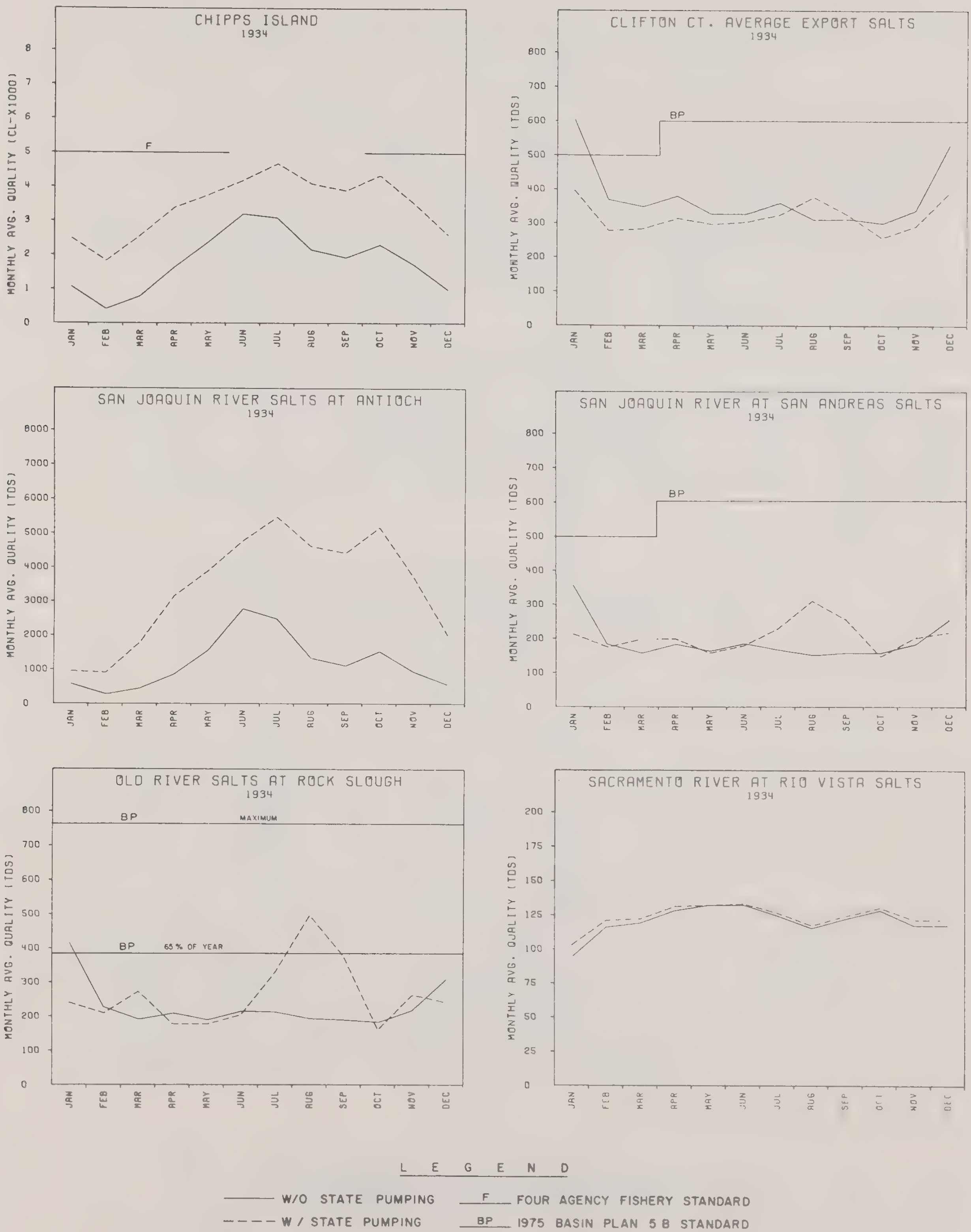


Figure 14c PROJECTED SALINITIES, CRITICALLY DRY YEAR (1934)

extending from Rio Vista and Jersey Point westward to the Carquinez Strait, a time-variable model projected water quality variations over each of the annual periods investigated.

Results of the Central Delta analysis of are presented for five selected regions not shown distributed throughout the Delta. Chlorophyll projections are summarized on Figure 15, and dissolved oxygen projections are summarized on Figure 16.

4.119 Differences between the "with pumps" and "without pumps" cases are considered relatively small with the following exception. In the Franks Tract region under the wet year hydrology, the projected chlorophyll concentration in the "with pumps" case is 46 ug/l, while the value for the "without pumps" case is 78 ug/l. Examination of the details of the calculations shows that in the "without pumps" case, the flow in Old River near Franks Tract is toward the north, from the vicinity of Mossdale. These waters are nutrient-rich and stimulate algae growth in the shallow waters of Franks Tract. In the "with pumps" case, however, Old River flow is southward, away from Franks Tract and toward the Pumping Plant, and this nutrient source is significantly reduced.

4.119 The higher chlorophyll levels projected in the Franks Tract region for the "without pumps" case under wet year conditions are accompanied by higher dissolved oxygen concentrations. Dissolved oxygen in this region for the wet hydrology is projected at 10.4 mg/l without pumps and 8.8 mg/l with pumps. The difference is due primarily to higher photosynthetic production by the greater phytoplankton populations projected in the "without pumps" case.

4.120 The results presented for the Franks Tract region under the critically dry hydrology must be qualified. The model used in the Central Delta analyses has not been calibrated with low flow data, and projected chlorophyll levels near Franks Tract are higher than those observed in the field during the drought years 1976 and 1977. The chlorophyll levels presented may therefore be overstated. The possible impact of this possibility on dissolved oxygen concentrations has been assessed by auxiliary projections which remove the effect of phytoplankton photosynthesis, respiration and decay from the dissolved oxygen calculations. The resulting calculations show that the effect of removing the phytoplankton in either the "with pumps" or "without pumps" case under the critically dry hydrology is to reduce projected dissolved oxygen concentrations in Franks Tract from 8.2 mg/l to a minimum of about 7.4 mg/l.

4.121 The Western Delta-Suisun Bay analysis, like that in the Central Delta, deals with projected variations in the distributions of phytoplankton levels and dissolved oxygen concentrations as impacted by Delta Pumping Plant operations. The phytoplankton results are summarized in terms of projected chlorophyll concentrations in Sherman

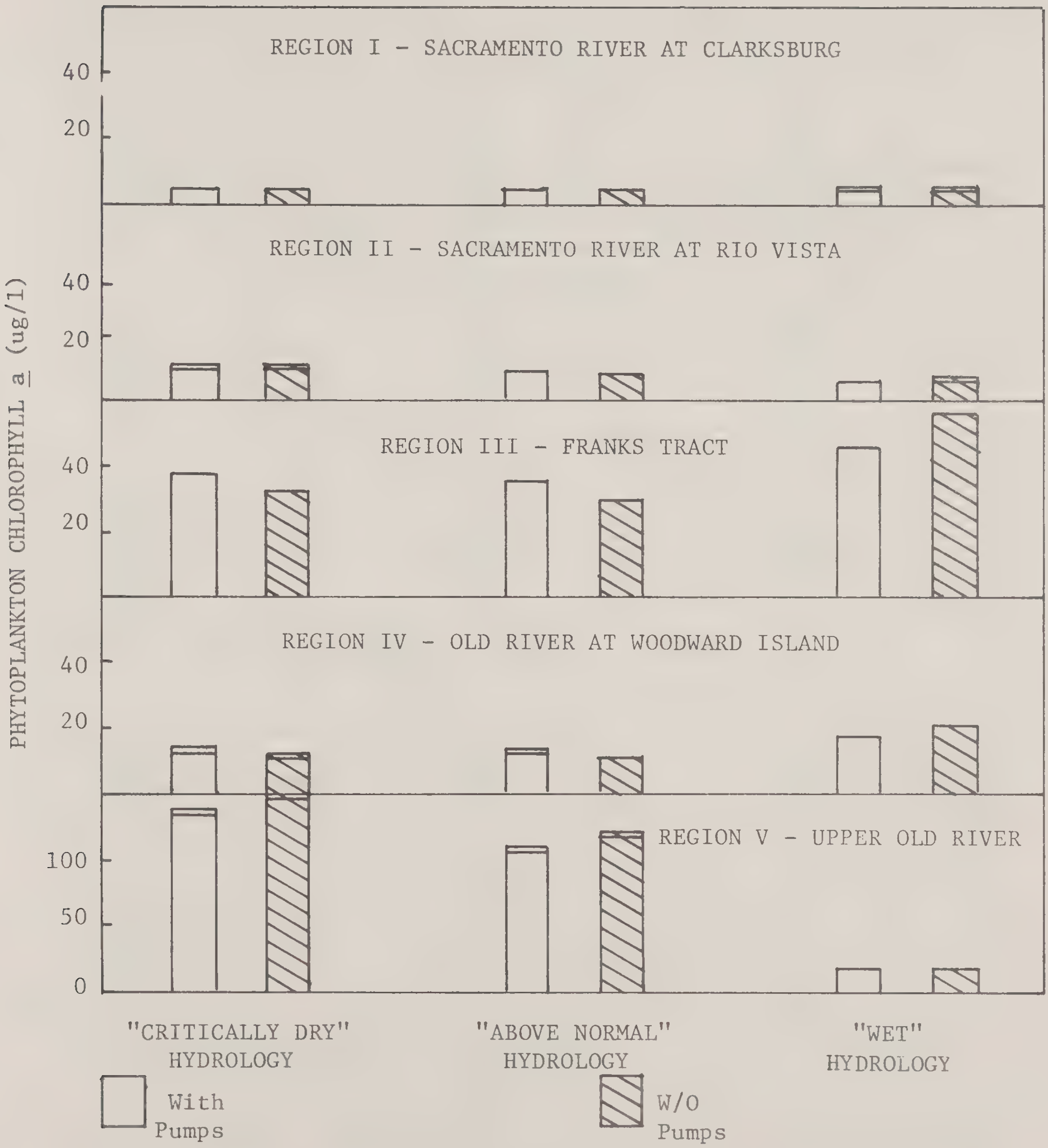


FIGURE 15

PROJECTED SUMMER AVERAGE
CHLOROPHYLL a FOR CENTRAL DELTA

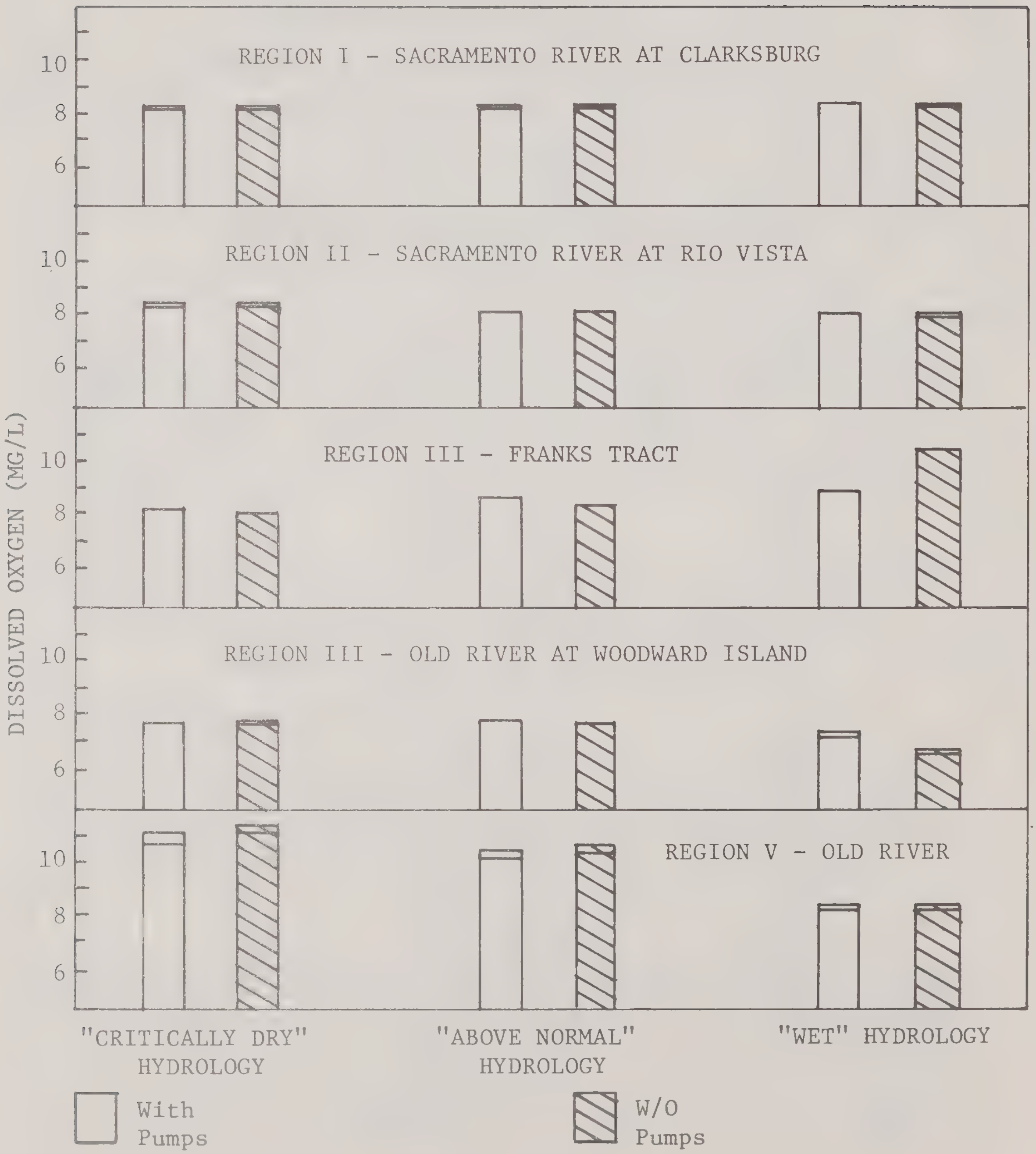


FIGURE 16

PROJECTED SUMMER AVERAGE DISSOLVED OXYGEN FOR CENTRAL DELTA

Lake, Honker Bay and Crizzly Bay, three shallow, relatively productive zones within the study area. Figure 17a presents projections for the "with pumps" and "without pumps" cases under the critically dry hydrology for the three zones. Results for the normal hydrology are shown on Figure 17b, and results for the wet hydrology are shown on Figure 17c.

4.122 In each case, the projected impacts of Pumping Plant operations are considered relatively small. The maximum projected impacts are about 4-6 ug/l, occuring in each of the three zones under the critically dry hydrology. Under this hydrologic condition, higher chlorophyll levels are associated with the "without pumps" case, which has higher Delta outflows than the "with pumps" condition. These results are due in part to an empirical relationship incorporated in the model with reduces the phytoplankton growth rate as ocean salinity intrusion increases.

4.123 In terms of dissolved oxygen concentrations, review of the details of the calculations shows for all hydrologic conditions differences between the "with pumps" and "without pumps" cases are in the 0-0.2 mg/l range throughout the study area. Average dissolved oxygen concentrations are generally above 7.5 mg/l throughout the region.

Fishes in the State Aqueduct System.

4.124 Since 1968, young striped bass and other species have been imported to San Luis Reservoir, O'Neill Forebay, and adjacent canals with water pumped from the Delta by the CVP and SWP. Striped bass, catfish, and other species are found in varying abundance throughout most of the California Aqueduct system.

4.125 A popular striped bass fishery developed at the San Luis Reservoir complex. These fish are probably maintained entirely by export pumping, since there is no evidence of successful spawning at the reservoir. Based on postcard surveys, the catch at San Luis averaged 112,000 bass from 1970 through 1974.

4.126 Effects on Suisun Marsh. - The SWP diversions increase the frequency and severity of salt water intrusion into the channels adjacent to Suisun Marsh. Under the Four-Agency Standards, Department of Fish and Game evaluations show that channel salinities will be high enough by 1980 so that waterfowl food supplies in large areas will be severly reduced in critically dry, and about one-half of the below normal years, or about 41 percent of the time.(15)

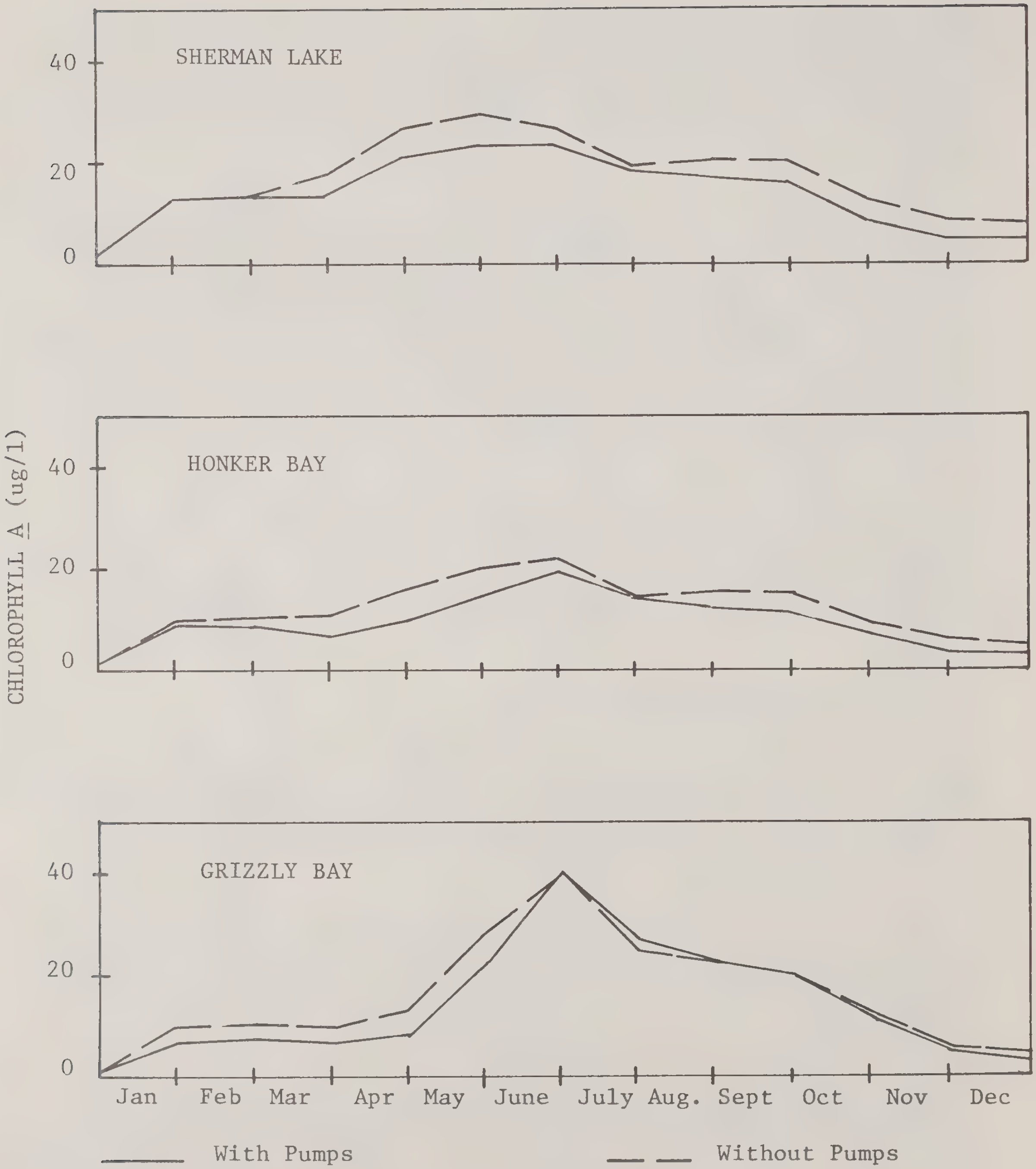


FIGURE 17a

WESTERN DELTA - SUISUN BAY CHLOROPHYLL PROJECTIONS
CRITICALLY DRY HYDROLOGY

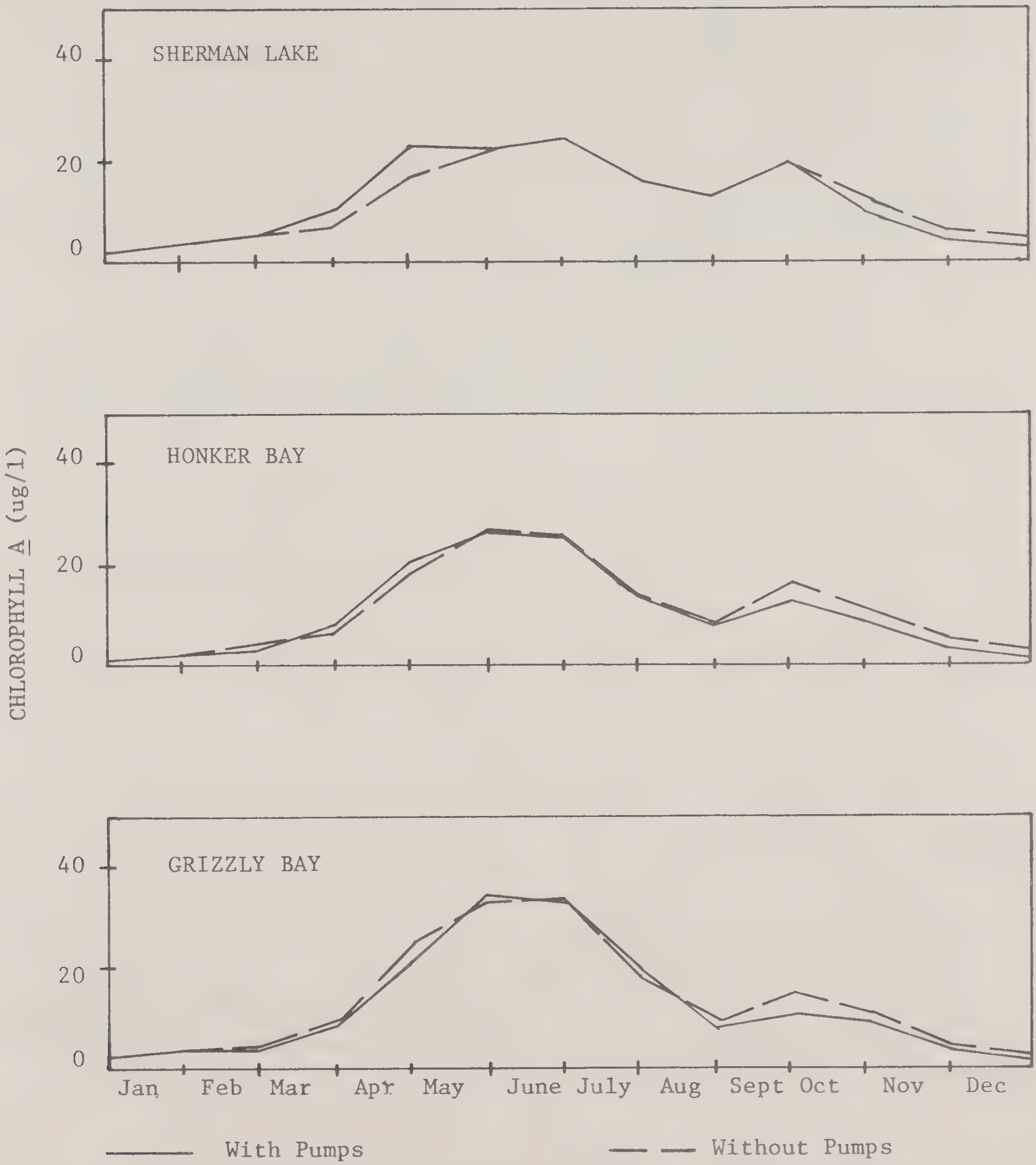


FIGURE 17b

WESTERN DELTA-SUISUN BAY CHLOROPHYLL PROJECTIONS
ABOVE NORMAL HYDROLOGY

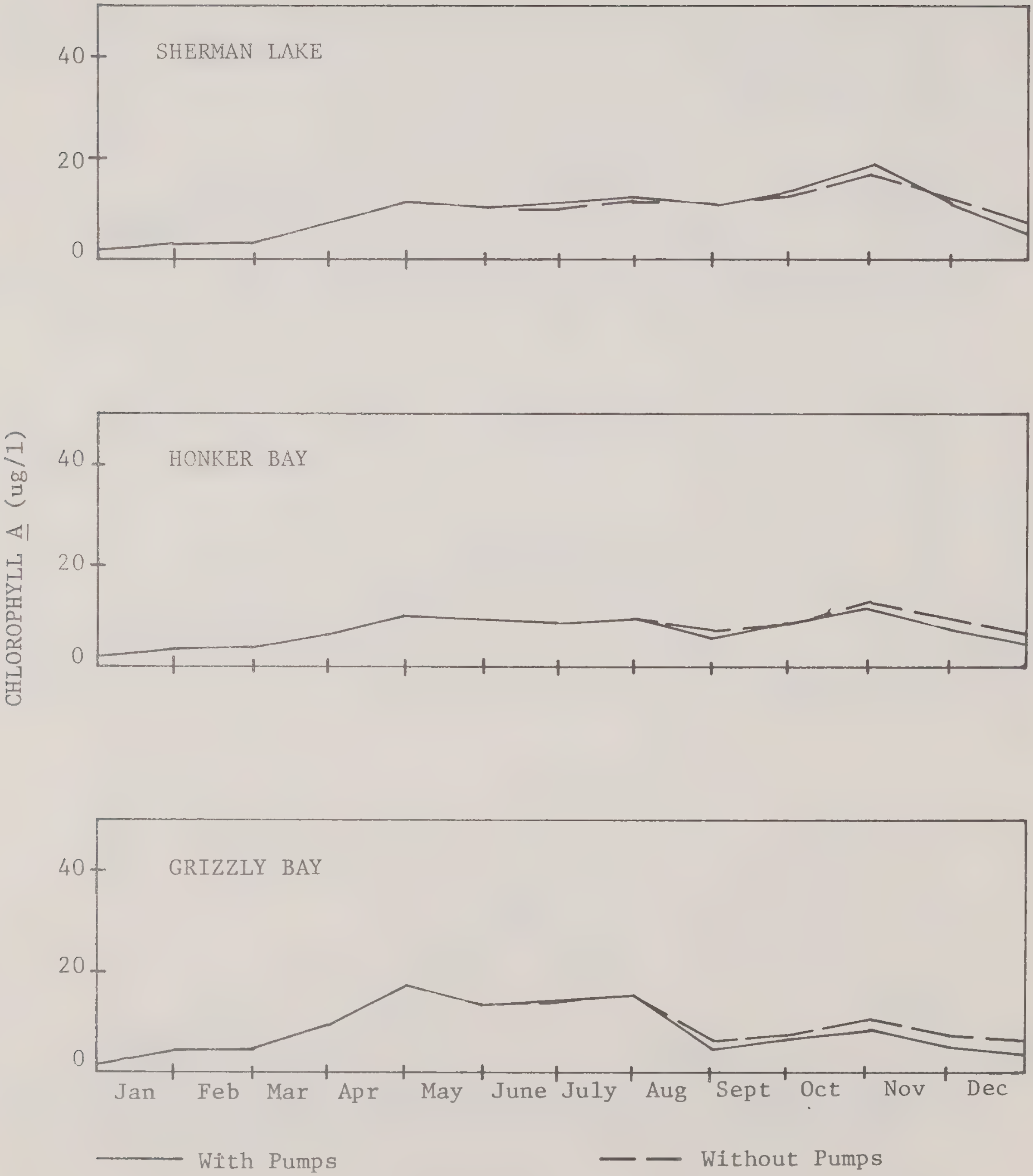


FIGURE 17c

WESTERN DELTA-SUISUN BAY CHLOROPHYLL PROJECTIONS
WET HYDROLOGY

4.127 The managed, leveed marshes: Alkali bulrush seed is the most important waterfowl food item in the marsh. Its production depends on soil salt concentration, primarily during May. Figure 18 shows the relationships of alkali bulrush seed yield to (a) May soil salinity, and (b) length of soil submergence. Optimum salinity in May is about 9 ppt TDS. Seed production at or above 80 percent of maximum can be attained within a range of 7 to 9.5 ppt TDS. The reduction in seed production on soils with salt levels below 9 ppt is related to competition between plant species and not to the effect of lowered salinity. Studies show that the ratio of seed weight to plant weight remains high in all instances of low salt concentration.

4.128 The length of soil submergence also affects seed yield. More than about 6 months submergence significantly increases yield. However, May salt concentrations of about 25 ppt TDS or higher probably prevent seed production regardless of the length of soil submergence.

4.130 Precise determination of required salinity of applied water to achieve a desired soil salinity would have to consider a host of variable environmental factors, including soil structure and the efficiency of water control facilities. No method has yet been established for such a precise determination.

4.131 Studies by the Departments of Fish and Game, Water Resources and the U. S. Soil Conservation Service have demonstrated two fundamental relationships. First, the salinity of pond water in the marsh increases by 4-5 ppt TDS during October. This is attributed to the dilution of surface salts deposited during the dry summer months. This increase is reduced to approximately 2 ppt TDS by the end of November and, where circulation is efficient, is virtually eliminated by the end of December. Second, the ratio of soil salinity to surface water salinity is normally about 2:1 in a steady state condition but can be reduced below 2:1 by repeated leaching. Leaching is best accomplished with applied water substantially less saline than the existing soil salinity. Further, when water is applied to saturated soils of a nearly equal salinity, equilibrium is reached relatively slowly, giving rise to low soil and surface water salinity ratios in April and May, as depicted in Table 8.

TABLE 8

Salinity of Applied Water Required to Maximize Alkali Bulrush Seed Production and Achieve 60 Percent Seed Germination. 1/

	Applied Water Salinity		Soil Water Salinity		Ratio of Soil Water Salinity to Applied Water Salinity
	EC (mmhos)	PPT TDS	EC (mmhos)	PPT TDS	
Oct	18.8	12 2/	50.0	32	2:1
Nov	15.6	10 3/	37.5	24	2:1
Dec	15.6	10	31.2	20	2:1
Jan	12.5	8	25.0	16	2:1
Feb	7.8	5	15.6	10	2:1
Mar	7.8	5	14.1	9	1.8:1
Apr	10.9	7	14.1	9	1.3:1
May	10.9	7	14.1	9	1.3:1

1/ These applied water salinities assume the following conditions are met:

a) The existence of reasonably efficient water control facilities.

b) The completion of at least two leaching cycles in addition to the January and June drainages.

c) The ponds remain flooded for 7 months.

2/ The salinity of water applied in October dissolves surface salts and is increased by 4 ppt TDS.

3/ The salinity of water applied in November is increased by 2 ppt TDS due to residual surface salts.

4.132 The effect of the SWP pumping plant on alkali bulrush seed production was evaluated using the channel salinities at Port Chicago predicted by the previously described salinity model runs. Figure 19 shows the results. Port Chicago values were converted to high tide and TDS, and transposed to the mouth of Suisun Slough by a .75 factor, along with historical and required salinities shown in Table 8.

The salinities predicted for wet years make it unlikely that the pumping plant will have any measurable adverse impacts on the marsh during such years.

4.133 For the above normal year, both "with" and "without" conditions produce spring salinities in excess of historic values. With the pumping plant fall salinities exceed both historic and required levels, which will result in reduced wildlife habitat and recreational values. Also, a proportionally greater amount of salt will remain in the soil during the winter which must be removed by spring leaching. The incremental loss of leaching efficiency caused by project operation compounds an already deteriorated water quality condition, and results in minimally adequate salinities. A decline in waterfowl food production can be expected on Ryer, Roe, Freeman, Simmons, Dutton and Wheeler Islands unless existing management practices and water control facilities are improved. A reasonable estimate of the loss is 10-20 percent. Since these islands support about 16 percent of the alkali bulrush stands in the marsh, this amounts to a 2 to 3 percent reduction for the marsh as a whole. The relatively severe impact attributed to project operation on these islands as a result of minor increase in channel salintty needs further explanation. Alkali bulrush is extremely sensitive to soil salinity when setting seed in May and salt induced stress at this time results in dramatically reduced seed yield

4.134 "With" and "Without" salinity predections were not made for below normal and dry years, prohibiting a detailed assessment of the inpact of project operations during these types of years. However, salinity predictions presented at the SWRCB's Delta hearings for such years exceeded those for above normal years. Therefore, it appears that SWP diversions would substantially reduce seed production during below normal and dry years.

4.135 Historically (1926-67), water qualities in average critically dry years were fresh enough to produce optimum alkali bulrush seed production with proper marsh management. Studies show that this will no longer be true in future years, either with or without SWP diversions. Table 9 shows critical year estimated seed production with and without the project at three locations that normally produce 62 percent of total seed production in the marsh.

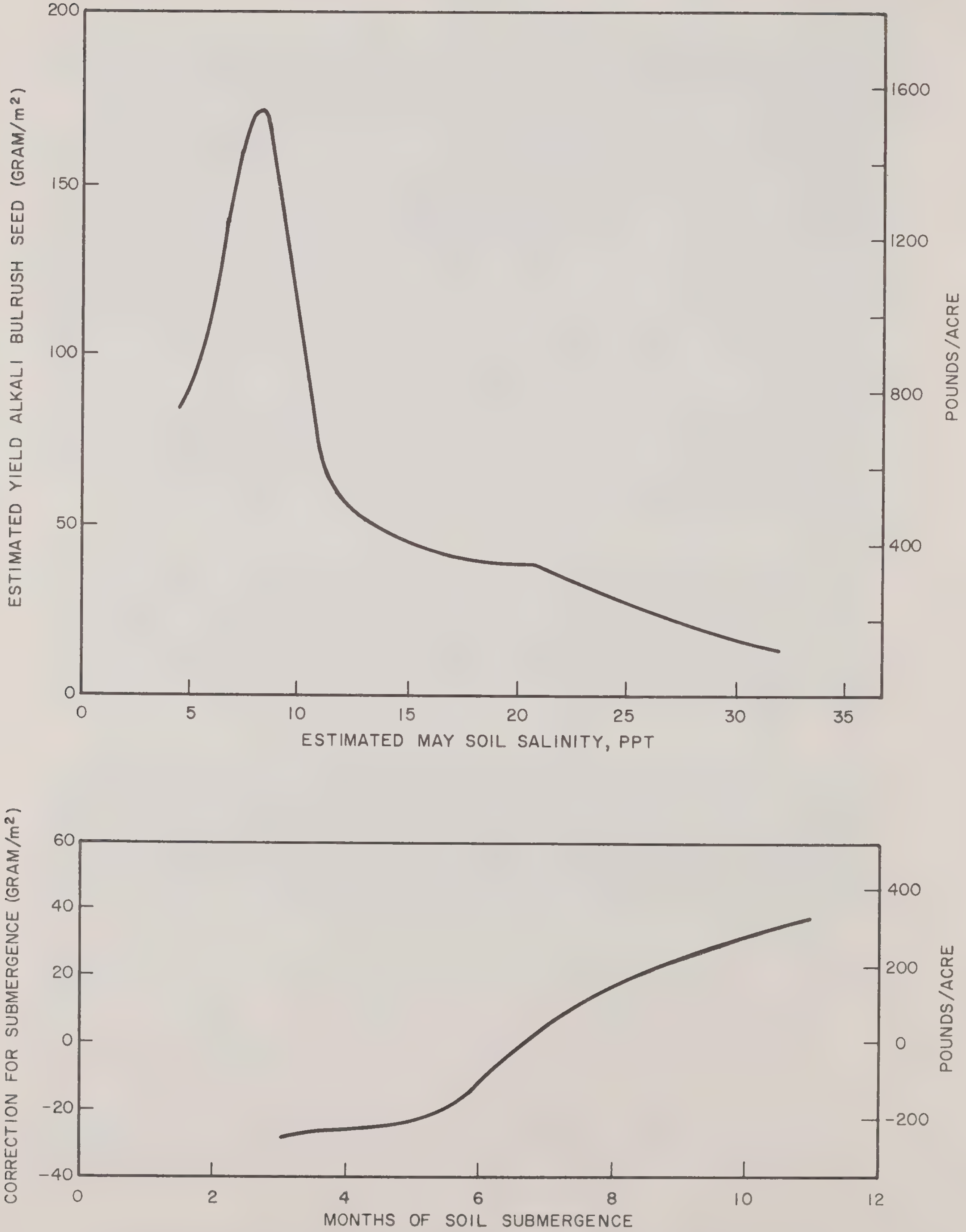


FIGURE 18 THE RELATIONSHIP OF ALKALI BULRUSH SEED YIELD TO MAY SOIL SALINITY AND LENGTH OF SOIL SUBMERGENCE

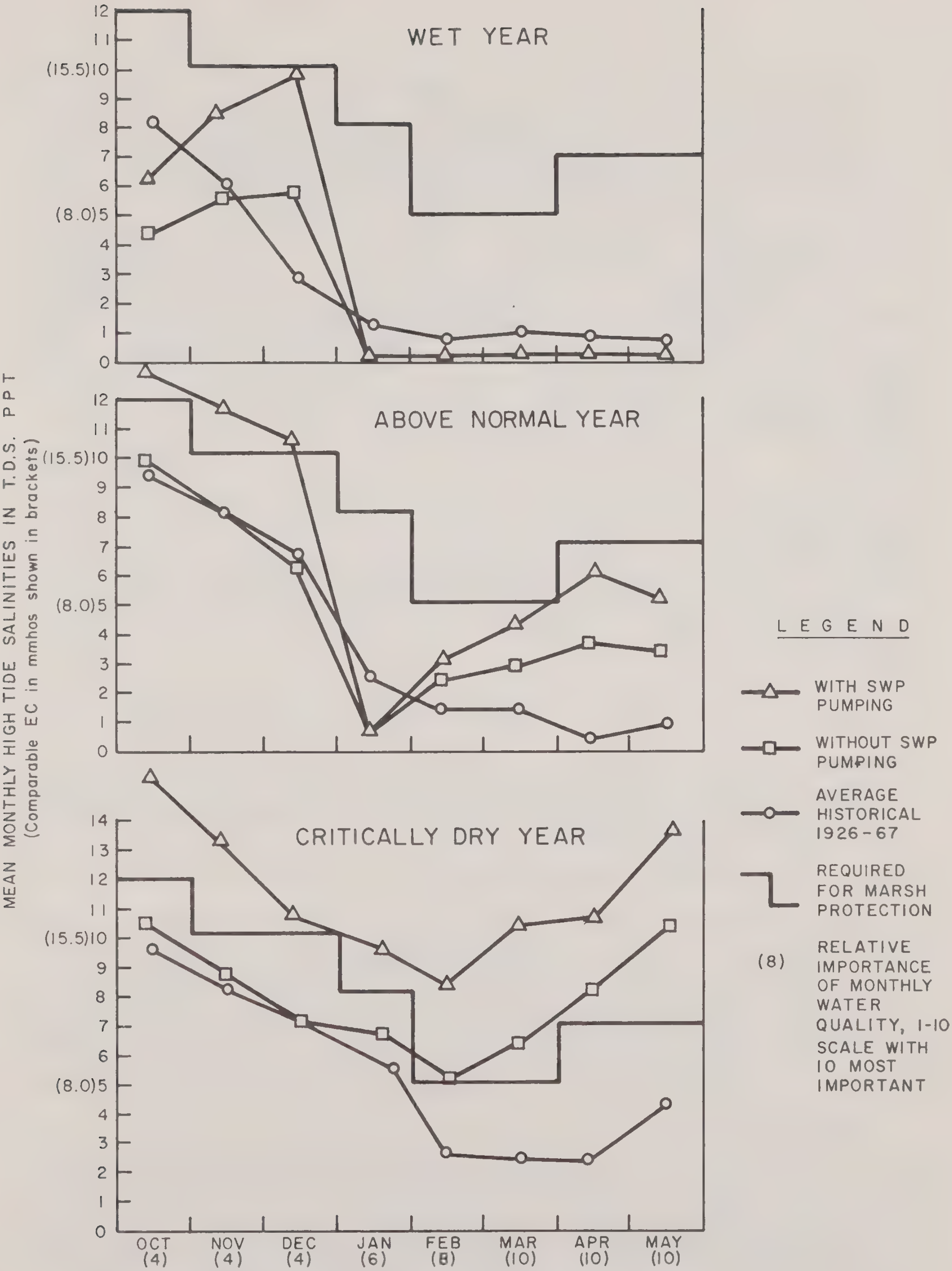


Figure 19 PREDICTED CHANNEL SALINITIES AT SUISUN MARSH, 1980 LEVEL

TABLE 9

Estimated Effect of State Pumping
on Production of Alkali Bulrush Seed
in a Critically Dry Year1/

Location	Percent of Marshwide Production	Percent of Optimum: Historical	Percent of Optimum: Without SWP	Percent of Optimum: With SWP	Percent of Marshwide Optimum: Without SWP	Percent of Marshwide Optimum: With SWP
Suisun Slough and W. Grizzly Island (8000 ac.)	46	100	63	34	29.0	15.6
Simmons and Wheeler Islands (4000 ac.)	14	100	34	26	4.8	3.6
Channel Islands2/ (1000 ac.)	2	100	34	26	0.7	0.5
Totals	62				34.5	19.7

1/ Estimates based in assumption of efficient marsh management including at least two spring leaching cycles.

2/ Ryer, Roe, Freeman, and Snag Islands.

4.136 Table 9 shows that marshwide seed production is reduced an additional 15 percent in a critically dry year by State pumping. These estimated yield reductions are conservative since they assume best possible marsh management practices, which will not always be the case. Such a loss of food production reduces the waterfowl holding capacity of the marsh and adversely affects a large segment of wintering waterfowl.

4.137 In addition to the immediate impact on seed yield in a critically dry year, the severe conditions will stress the food plants (most of which are perennials) to the extent that yields will be reduced the following year. Should two or more critical years occur in sequence, the result will be large scale vegetative changes with undesirable salt-tolerant plants such as pickleweed and saltgrass replacing food plants. This occurred to some extent during the 1976 and 1977 droughts. Some marsh areas may take several years to recover from dry and critically dry year conditions.

4.138 Pumping operation will also reduce uncontrolled outflow that provide the marsh with a valuable flushing action. Uncontrolled spring outflows also afford the managed wetlands a margin of safety by offsetting poor management and facilities with extremely fresh water. With the pumps in operation, even in an above normal year, it will be necessary to manage very efficiently and complete at least two spring leaching cycles to achieve maximum seed production. This cannot be achieved on some of the lower marsh areas with existing facilities.

4.139 In summary, the SWP Pumping Plant reduces waterfowl food production in all but wet years. Critically dry rainfall years occur 12 percent of the time, dry 20 percent, below normal 18 percent, above normal 18 percent, and wet 32 percent. Thus, SWP pumping will result in reduced waterfowl food supplies in approximately 68 percent of all future years.

4.140 Overall, the waterfowl habitat is threatened by progressive degradation, not imminent destruction, as the water quality in the bays continues to degrade if mitigating measures are not taken. The 1976 and 1977 droughts demonstrated that the managed wetlands adjacent to and supplied from the bays are vulnerable to severe damage from salinity intrusion resulting from the minimum critical year Delta outflows.

4.141 Mitigating measures for the managed wetlands:

Many public agencies have statutory responsibility involving the Suisun Marsh and are coordinating planning efforts for short and long-term marsh protection. Proposed mitigation measures consist of a combination of regulated Delta outflows and water quality objectives, improved marsh management, and new physical facilities.

4.142 The SWRCB's approach to marsh protection is to specify water qualities that are to be maintained in the waters surrounding the marsh as a condition of CVP-SWP operations "...until a suitable alternative water supply is provided...". The public agencies responsible for the protection of the marsh generally agree with the SWRCB's position that the marsh cannot be protected solely by regulating Delta outflow using project reservoir storage.

4.143 The SWRCB's Water Quality Control Plan and D-1485 specifies a compliance date for full mitigation in the marsh by October 1984. Prior to that time, the interim standards will strengthen marsh protection over the 1975 Basin Plan Standards. The interim standards guarantee full protection only in wet years, with recognition that portions of the marsh would incur habitat degradation ranging from moderate in above normal years to severe in critically dry years.

4.144 The SWRCB concluded that minimum compliance with the water quality standards would result in the following impacts on alkali bulrush seed production:

	Percent of Optimum Alkali Bulrush Seed Protection	
Rainfall Year	Channel Islands	Suisun Slough and west Grizzly Island areas
Critical	Up to 10	Up to 20
Dry	10-30	20-35
Below Normal	No Data	No Data
Above Normal	20-30	20-35
Wet	100 1/	100 1/

1/ Calculated and included for this report.

The Suisun Resources Conservation District is designated under the Suisun Marsh Preservation Act as the agency to prepare and administer a management program designed to preserve, protect, and enhance the plant and wildlife communities within the primary management area of the Marsh. This program is to be submitted to BCDC for certification during 1979. The Department of Fish and Game and the Soil Conservation Service are assisting in this program.

4.145 An integral part of the overall protection program is the development of marsh management plans for each individual ownership in the Marsh. Implementation of the plans is essential for the maintenance of wildlife habitat at optimum levels and the efficient use of facilities and water provided by the CVP and SWP as mitigation measures.

4.146 The four governmental agencies conducting the Interagency Ecological Study Program and involved in the proposed Four-Agency Fish and Wildlife Agreement have scheduled completion of an overall Suisun Marsh management plan for late 1979, which was intended to provide full protection to all managed marshlands by January 1982. The latter date has since been found unrealistic and was modified in the SWRCB's plan to fall 1984. The Four-Agency plan will detail the permanent water facilities, management schedules, and recommended practices as well as the institutional arrangements needed to implement the plan. The plan will be included in the USBR's feasibility report on the Solano County Water Project.

4.147 The measures required for full mitigation and possible marsh enhancement have not yet been identified. However, the four agencies agree that planning is sufficiently advanced to identify initial facilities that will be part of the overall plan. The present schedule calls for completion of the initial facilities by October 1980.

4.148 The initial facilities can provide early protection for the more vulnerable areas of the Marsh, those adjacent to and served by diversions from Suisun, Honker, and Grizzly Bays. They would permit shifting the source of water for those "bayside clubs" from the bays to the interior channels, where the better quality from stream runoff persists long after the quality in the bays has degraded.

4.149 The initial facilities are:

(A) Water control and management facilities required to deliver water from Montezuma Slough taken from a point southeast of Meins Landing onto certain managed wetlands areas that are located on Grizzly, Simmons, Wheeler, Dutton, Van Sickle, and Hammond Islands and presently flooded with water from Honker, Suisun, and Grizzly Bays.

(B) Water control facilities required to deliver water from Goodyear Slough onto all adjacent managed wetland areas and drain water from Goodyear Slough into Suisun Bay.

4.150 The initial facilities are not expected to measurably affect salinities, or project impacts, in Suisun Slough, Montezuma Slough, or Grizzly Bay, nor will they affect the channel islands (Snag, Roe, Freeman, and Ryer). Protection for the former areas and mitigation for the channel islands must be provided for in the permanent plan. However, with the initial facilities, alkali bulrush seed production on Simmons, Dutton, and Wheeler Islands (4,000 acres supporting about 14 percent of the bulrush) would be optimized even in a critical year.

TABLE 10

SWP Deliveries 1/ in 1980
(Values in 1,000 acre-feet)

Service Area	Use: Agriculture	Use: M & I	Use: GWR 1/	Total
South Bay	4.6	83.2	47.0	134.8
San Joaquin Valley	691.7	53.9	19.4	765.0
Southern California	56.3	916.3	293.3	1,265.9
TOTALS	752.6	1,053.4	349.7	2,165.7

1/ Surplus Requests not shown.
2/ Ground Water replenishment.

Unleveed tidal marshes:

4.151 The degradation of tidal waters, partially attributable to SWP diversions, will result in a change in the speciation of plants in the

intertidal marshes on the channel side of the levees. The increased salinity and vegetation changes will have other effects that cannot be quantified at this time, nor can the degree to which the SWP is responsible. Major uncertainties are: (1) The present salinity tolerances of the plants, and (2) the balance between benefits derived from SWP releases, improvements in summer and fall salinities, and detriments due to increased salinities at other times of the year.

4.152 The vegetative conversion process will include the gradual replacement of "tules" with cordgrass and low-yield stands of alkali bulrush. The water released from storage during the summer and early fall that is necessary to insure that adequate water quality is delivered to the export pumps (carriage water) will result in lower bay salinities in many years than would exist without the pumps in operation and will tend to ensure a gradual vegetation transition. However, degraded channel salinities resulting from a succession of dry or critical rainfall years, aggravated by Delta exports, will accelerate the loss of tules thus denuding tidal berms and islands and subjecting them to greater wave erosion and potential destruction. Such berms and islands presently protect bay-front flood control levees from wave erosion on Morrow, Joice, Simmons, Wheeler, Grizzly, Ryer, Roe, Snog, and Freeman islands. This is an extremely important function, since most of the bay-front leves are composed primarily of a combination of peat and silt dredged from adjacent tidal sloughs and can erode rapidly when subjected to wave action. For the most part these levees are poorly maintained and those not now protected by such berms are frequently damaged during high runoff conditions. The loss of these protective berms would ultimately increase levee maintenance and, in the event of levee failure, management costs for the affected wetlands.

4.153 Habitat on higher elevations, which is subject to infrequent flooding and subsurface tidal irrigation, would change from the present mixture of baltic rush, olney bulrush, alkali bulrush, mixed grasses, pickleweed, and saltgrass to predominatly pickleweed and saltgrass. The most profound changes would occur in the most westerly marshes bordering Suisun and Grizzly bays from Ryer Island to west of Benicia. A series of dry and critical years could produce temporary vegetative changes in Suisun and Montezuma Sloughs and in Suisun Bay as far east as Chipps Island.

4.154 The combination of vegetative changes and higher salinities is expected to decrease the range and density of aquatic mammals such as mink, otters, beavers, racoons, and muskrats in these areas. Birds that depend heavily on tule stands for nesting and feeding cover would be displaced. Such birds include the Virginia and Sara rails, coots, red-winged blackbirds, marsh wrens, black-crowned night herons, and American bitterns. However, habitat for California clapper rails, black rails, and salt-marsh harvest mice would be improved and populations of these species are expected to increase. This may be

considered a benefit of water projects, since all three species are either rare or endangered.

4.155 The increased salinity is expected to increase the variety and abundance of benthic invertebrates, which in turn would probably increase the density of their major avian predators such as rails, shorebirds, and diving ducks. Seventy percent of the canvasback ducks wintering in California now utilize San Pablo and San Francisco Bays as their wintering grounds. The increase in benthic fauna expected to occur in Suisun and Grizzly Bays may provide additional winter habitat for this species. The abundance of this species is somewhat unstable and although no hard evidence exists that the size of existing wintering grounds is limiting, this species would benefit to some extent by water project operation.

4.156 Fish diverted into the aqueduct system cannot return to the Delta. The water and fish conveyed through the Delta Pumping Plant sustain recreation use at all SWP facilities south of the Delta. This use amounted to about 3,131,000 recreation-days in 1975, a 7 percent increase from use in 1974. About 97 percent of the 1975 use occurred at the major reservoirs, while the remaining 3 percent occurred at fishing access sites along the California Aqueduct.

4.157 <u>The Effects of Delta Pumping Plant Operation on the Service Areas</u>:

<u>South Bay Service Area</u>: Table 10 shows current SWP contractor requests for 1980 entitlement deliveries for the South Bay area and the other SWP service areas. In the Santa Clara Valley Water District, SWP water supplements the district supply, and if allocated to the estimated 1980 population of the county, it would provide approximately 64 gallons per capita per day, or 40 percent of the total district use in that year. SWP water enables the improvement of the groundwater basin by eliminating the need for overdraft, which results in a degradation of groundwater quality and land subsidence.

4.158 SWP water accounts for approximately 78 percent of the expected 1980 water supply in Alameda County Zone 7 Water District. The supply prevents an overdraft of groundwater to meet demand and allows the district to reduce the hardness of water supplies by 150 mg/liter.

4.159 In 1980 SWP water will account for 46.9 percent of the total water supply for the Alameda County Water District. The provision of state water improves the quality of water in the groundwater basin and prevents saltwater intrusion from the San Francisco Bay into the basin.

4.160 The analysis indicates that in each of the above three districts population growth and land use changes occurred for reasons other than the availability and delivery of SWP water. However, the SWP water does meet the increased demand generated by that population

growth and is used to protect against environmental impacts that would occur if the districts relied on groundwater pumping to meet an increased demand for water supply.

4.161 The land use activities in the South Bay service area have no direct casual connection with SWP deliveries. It has been determined, therefore, that the project does not affect the air quality of the basin.

4.162 As mentioned previously, concerns have been expressed about reductions of high winter outflows from the Delta due to CVP-SWP operations and the resulting effects on the flushing of wastes from the San Francisco Bay complex. Also, as previously discussed, the flushing of pollutants is related to water circulation and density stratification, which in turn are partially dependent upon the magnitude and frequency of winter and spring floodflows. Presently, there is insufficient knowledge to define the effects of outflow on the Bay. It may be impossible to produce satisfactory conditions in the Bay by the use of Delta flows alone. Under floodflow conditions, the CVP-SWP diversions have only a minor effect on Delta outflows, and therefore, a minor effect on water circulation in the Bay.

4.163 Under summer flow conditions, Bay water circulation is dominated by tidal action. At such times, the effect of CVP-SWP diversions on Bay circulation is also negligible, except perhaps in the Suisun Bay area under dry year flow conditions. In that area under such conditions, the extreme effects of SWP diversions only could be about a 10 percent increase in pollutant levels. This percentage increase is based upon the relationships between pollutant levels and outflows evaluated in a dispersion study report (30), together with the dry year outflows and SWP diversions determined in the 1980-level operation studies.

4.164 <u>San Joaquin Valley Service Area</u>:

The principal use of SWP water in the San Joaquin Valley service area is irrigated agriculture, accounting for nearly 99 percent of water delivered to the area in 1975. Almost half of this water was delivered to areas with no alternative water supply. The flow of SWP water provides an economic base for agricultural development of formerly dry barren lands.

4.165 Irrigated croplands in the SWP service area are considered to be at least as productive as older, more established locations in the San Joaquin Valley. Cotton is the principal crop in the State service area, with about 20 percent of California's cotton production originating here.

Over 222,000 acres of irrigated agriculture directly attributable to SWP water deliveries are projected for 1980, assuming entitlement

deliveries only. (In 1975, 385,000 acres were attributed to SWP entitlement and surplus deliveries totaling about 50 percent more than the projected 1980 entitlements) The value of crops grown is projected to be $156 million, providing jobs for nearly 9,000 agricultural workers.

4.166 This agricultural production will stimulate other sectors of the economy, not only in the San Joaquin Valley service area, but also in other areas of the State. It is estimated that over 2,000 additional jobs will be created in agriculture, manufacturing, wholesale and retail trade, services, and other industries. Housing attributible to SWP deliveries is 11,000 units. Total direct and indirect income of over $245 million is projected to be generated by San Joaquin Valley service area agricultural production.

4.167 Air quality would be adversely affected by agricultural activities in the form of particulate matter caused by agricultural tilling and burning. Agriculture is a relatively small source of oxidant problems through emissions from farm machinery and from use of pesticides.

4.168 In the San Joaquin Valley service area, the substitution of SWP water for groundwater supplies has been a major impact. Of the eight-member units of the Kern County Water Agency which received State water in 1975, five were using the water, in part, in lieu of groundwater. All of the six remaining SWP agricultural contractors use project water as a full or partial substitute for groundwater. Subsidence in the southwestern portion of the Valley has been arrested since imports began.

4.169 The Tulare Lake Basin, which lies south of the drainage division between the San Joaquin and Kings Rivers, is essentially a hydrologically closed basin. Consequently, most of the salts brought to the irrigated lands, primarily through application of chemicals and water, tend to accumulate in the soils and subsurface waters. It has been calculated (33) that about 330 million tons of salts occur in the top 20 feet of soils in the Tulare Lake Basin and that about 1.6 million tons of salts are being added each year.

4.170 The drainage problem area is defined as the area that is underlain by brackish water within five feet of the ground surface. Presently, in the Tulare Lake Basin, the problem area exceeds 240,000 acres. Use of SWP water has contributed somewhat to the increase in the drainage problem area in Tulare Lake Basin. Presently, the portion of the drainage problem area being irrigated with SWP water is approximately 6,500 acres, an apparent increase from about 2,000 acres under preproject conditions.

4.171 If nothing is done to correct drainage problems, lands will go out of agricultural production and the poor quality of perched water

will degrade underlying water supplies. Evaporation ponds are presently being used by individual farmers and a drainage district to dispose of drainage water in the Tulare Lake Basin. A management plan for drainage waters is being developed by the Interagency Drainage Program mentioned in Chapter I. The plan will include collection, reuse, and disposal of saline water for the entire San Joaquin Valley.

4.172 Southern California Service Area:

The total water demand for the Southern California service area is projected to be around 4.14 million acre-feet in 1980. Approximately 1.2 million acre-feet will be delivered by the SWP, about 867,000 acre-feet will be contracted from the Colorado River, and the remaining 2.17 million acre-feet will be taken from local sources, including rivers, streams, and groundwater, and Owens River imports.

4.173 The greatest benefit of SWP water to the Southern California service area is to the constituent agencies of the Metropolitan Water District (MWD), which receives over 90 percent of SWP deliveries. South of the Tehachapis. Serving more than ten million people, MWD boundaries encompass 125 incorporated cities which would import 1,057,000 acre-feet of SWP water in 1980, about 21 percent of their total water demand.

4.174 The Delta Pumping Plant and the aqueduct system have transported State water to MWD since 1972; most of this water is used for municipal and industrial purposes and groundwater replenishment. The availability of high quality State water to the Southern California service area has produced the following effects:

a. A reduction of the volume of water imported from the Colorado River, thereby saving pumping costs for commercially generated electrical energy which are at a rate approximately eight times the amount MWD pays for public power.

b. A reduction of the dependence on other alternative water sources that cannot offer as high a level of water quality as SWP water.

c. An increase in the potential use of reclaimed wastewater by lowering the total dissolved solids concentration (TDS) of wastewater.

d. A reduction in the continued depletion of groundwater.

e. An alleviation of public and private pressure to develop new sources of water such as desalting and new aqueduct systems.

f. The cessation of operation of MWD water-softening facilities originally constructed to treat Colorado River water.

g. A reduction in the costs of municipal treatment and water distribution systems due to higher quality water.

h. A potential savings of $22 to $34 million to private households in the costs of soap, detergents, cleansing agents, maintenance and replacement of water heaters, water-related appliances (washing machines, garbage disposals, etc.) and plumbing fixtures (1).

i. A decrease in the energy costs for heating high quality SWP water.

j. A decrease in the cost to industries for treating water; less demand for water filtration or distillation equipment.

k. A reduction in the use of water softeners, soaps, detergents, chemicals, and maintenance and repair of plumbing fixtures for laundries, restaurants, institutions, hospitals, etc.

4.175 Economic and population growth and land use changes have continued in the Southern California service area since SWP water was available in 1972, but the extent to which the SWP directly contributed to the growth cannot be ascertained. Likewise, changes in air quality are probably not related to the availability of SWP water.

4.176 Energy Requirements and costs. Estimated annual energy requirements for the existing Delta Pumping Plant, together with net on-peak capacity requirements for the aqueduct system, are shown in Table 11. For the above normal year, the plant's total energy requirements represent 0.5 percent of the projected 1980 requirements for all of California. The system capacity requirements for the same year represent 1.4 percent of the projected 1980 statewide peak demand, and 1.1 percent of the projected statewide generating capacity , which includes allowances for reserves. (Statewide projections for derivation of these percentages were provided by the State Energy Commission.)

TABLE 11
ESTIMATED ANNUAL ENERGY REQUIREMENTS
Existing Pumping Plant and Aquaduct System

Hydrologic Condition	System Net on Peak Capacity in KW	Delta Pumping Plant Energy Requirements in KWH		
		On Peak	Off Peak	Total
Critically Dry Year	218,648	119,781,828	547,941,345	667,723,173
Above Normal Year	501,065	332,042,281	619,012,256	951,054,537
Wet Year	310,315	320,565,674	686,435,066	1,007,000,740

4.177 SWP operating costs will increase sharply in 1983 when the existing energy supply arrangements expire. The amount of this increase cannot be determined with certainty at this time. DWR Bulletin No. 132-77 shows in Table B-3 projected power and replacement (relatively minor) costs for all SWP pumping and powerplants. For the Delta plant, such costs are projected to increase from $3.2 million in 1982 to $17.5 million in 1983, an increase of about $5.84 per acre-foot attributable to the higher power costs. These projections are based on melded costs of energy sources after 1982 equivalent to about 25 mills per kilowatt-hour.

4.178 The average changes for water delivered under SWP water entitlements are estimated to increase from $64 per acre-foot in 1982 to $100 per acre-foot in 1983. Most of the $36 per acre-foot increase is due to expected higher power costs to the SWP after the expiration of existing power supply arrangements.

5.00 ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED

5.01 Operation of the Delta Complex, in conjunction with other existing facilities of the SWP and CVP, takes into consideration the environmental impacts in the Delta and Suisun Marsh through compliance with applicable water quality standards, flow requirements, and, when necessary, export curtailments. Even with these operating procedures and constraints, SWP export diversions have various adverse effects which are presently unavoidable without mitigation measures that are incompatible with the primary purposes of the SWP. Important adverse effects are reviewed below.

5.02 Changed Delta Flow Patterns:

The SWP Pumping Plant, together with the CVP's Tracy Pumping Plant, modifies flows to various degrees in many Delta channels. The major adverse effects are along the San Joaquin River and in the channels south of the San Joaquin. These flow modifications increase the difficulties of meeting some water quality standards and export quality objectives. Frequently additional releases from storage are required for extra Delta outflow to provide the necessary water quality. Particularly severe in this regard are the flow reversals along the lower San Joaquin River, causing salt pickup from the western Delta. The export quality is degraded by the reverse flow conditions.

5.03 Aside from the problems of SWP and CVP operation, the flow modifications have adverse effects on the Delta fishery and aquatic fish food. Those include flow reversals in the central Delta and along the upper San Joaquin River and increased flows and velocities in the sourthern Delta channels. These effects are included in the following discussions of fish and invertebrates.

5.04 Fishes:

The SWP Pumping Plant reduces survival of young-of-the-year striped bass by an average of 23 percent over a series of years like 1968-1977. Higher flow velocities in water transport channels and consequent reduction in food supply may reduce growth and survival of one and two-year-old bass in the Delta. Increased salinity in the San Joaquin spawning area likely reduces the number of adults spawning there.

5.05 For Sacramento River king salmon, SWP pumping causes straying and delay of upstream migrant adults, increases movement of downstream migrant juveniles into the San Joaquin Delta resulting in increased mortality of migrants, and the loss of a small fraction of them at the SWP fish screen. San Joaquin River adults find orientation to "homestream" water more difficult because of increased quantities of

Sacramento River water in the Delta. The pumping plant also aggravates the low dissolved oxygen condition near Stockton in the fall which cause delays in the adult migration. Conditions for downstream migrant San Joaquin River salmon in the Delta are degraded by the pumping plant because of increased reverse flows and increased losses due to handling of young salmon at the SWP fish screens. Adverse effects of the pumping plant on steelhead are probably similar to the effects for Sacramento River salmon.

5.06 Juvenile American shad survival is probably reduced due to losses at the SWP fish screen and by alteration of normal migration routes. The pumping plant may reduce the supply of shad food organisms in the central Delta.

5.07 The SWP Pumping Plant reduces sturgeon year class abundance up to 17 percent if the relationship between water exports and white strugeon year class strength is a true cause and effect mechanism. The cumulative effect of many such reductions on subsequent spawning stocks might seriously depress the population.

5.08 The abundance of important food organisms for resident game fishes is depressed in water transport channels where net flow velocities are increased by the pumping plant. The pumping plant likely restricts white catfish distribution in the central Delta due to increased net velocities and in the western Delta because of increased salinity. White catfish do not respond well to the SWP fish screen and many are lost from the Delta along with the export water.

5.09 Although many resident nongame fishes probably are little affected by the pumping plant, some may be subject to adverse impacts. Increased flow velocities in water transport channels and increased salinity encroachment in the western Delta likely restrict and degrade the habitat of some native minnows. Large numbers of threadfind shad are salvaged at the SWP fish screen and, like American shad, many of these probably die during handling and transport. Many Delta smelt are also lost at the fish screen. Longfin smelt production may be reduced as much as 24 percent due to the reduced outflow caused by the pumping plant.

5.10 The pumping plant probably reduces <u>Neomysis</u> abundance in the estuary from 12 to 81 percent, depending on year type and phytoplankton populations. The greatest reductions probably occur in critical years and the least in normal years.

5.12 <u>Export of suspended Sediment</u>: At the present time, the depletion of suspended sediment from the estuary must be considered a potentially adverse impact of SWP and CVP diversions. The extent to which these depletions affect productivity and water quality in the estuary is being studies under the Ecological Study Program.

5.13 Drainage Problems in Tulare Lake Basin:

Use of water conveyed through the Delta Pumping Plant contributes to the salt balance and drainage problems in the Tulare Lake Basin. Presently, the SWP contribution represents 2.7 percent of the drainage problem area and about 0.14 percent of the land in agricultural production in the Basin.

5.14 Energy Comsumption:

Continued operation of the Delta Pumping Plant and other pumping plants in the system will require substantial capacity and energy.

5.15 Suisun Marsh:

Full protection of the managed wetlands in the Suisun Marsh through an integrated system of water control structures, overland supplies of fresh water and improved management practices will not be achieved until 1984. In the event of a critically dry year occurring before that, waterfowl food production on 8,000 acres of managed wetland on Grizzly Island and adjacent to Suisun Slough would be reduced from an estimated 63 percent of optimum without SWP pumping, to 34 percent with. Such a reduction in food supplies in this area, which presently produces nearly half of the alkali bulrush in Suisun Marsh, would significantly reduce the waterfowl holding capacity of the marsh.

5.16 Also, in a critically dry year, alkali bulrush seed production on the 1,000 acres composing the channel islands of Ryer, Roe, Freeman, and Snag would decrease to 26 percent of optimum as compared to 34 percent of optimum without SWP pumping. Although this adverse impact is unavoidable, it is possible to mitigate the loss by the improvement of other existing marshes or the development of new marshes elsewhere in the estuary.

5.17 Marsh management practices will become more costly to the landowners as a result of SWP Pumping Plant operations. Even with the proposed mitigation measures, increased channel salinities in critically dry, dry, and about half of the below normal rainfall years will require the application of effecient management practices and water control facilities to maintain the present level of water-fowl food production. Meeting these management may require the employment of a water master and/or caretaker at the landowners expense. Even with long range mitigation arrangements in effect, there will be additional operating costs accuring to the private landowners.

5.18 Increases above historic levels in the salinity of tidal bays and sloughs, partially attributable to SWP pumping, are expected to decrease the density and range of aquatic mammmals suich as beaver, mink, muskrat, and otter. Alsok terrestrial mammals dependent upon the tidal waters as summer drinking sources will be adversely affected. It is not possible to quantify the extent of such impacts.

5.19 The long-term salinity increase in tidal waters is expected to cause a change in the species of plants comprising the intertidal marshes, including the gradual replacement of tules at the western end of the marsh by cordgrass and low-yield stands of alkali bulrush. The numbers of certain tules dependent birds are expected to decline. The loss of tules would be accelerated during a succession of dry years, thus denuding tidal berms and islands and subjecting them to greater wave erosion. The loss of these protective berms would ultimately increase levee maintenance and in case of levee failure, management costs.

6.00 ALTERNATIVES TO THE PROPOSED OPERATION

6.01 The historic and proposed operation of the Delta Complex is affected by numerous factors, chief of which are (1) a variable water supply from the Delta, (2) a variable water supply in storage south of the Delta, and (3) the need to operate the entire aqueduct system in accord with energy constraints. The operational concept can generally be described as meeting contractual obligations and other needs to the extent possible within the constraints of water availability and system capability. Under this broad operating concept, annaul, monthly, daily, and hourly diversion and pumping rates are erratic.

6.02 Alternative operations considered involve additional operational limitations assumed applicable under the Corps of Engineers' permit, starting in 1980. They are:

a. Moderate reduction of pumping
b. Severe reduction of pumping, and
c. Cease pumping

A fourth conceivable alternative, involving prolonged pumping at full capacity, is also briefly discussed next in response to a point raised by the Court in the Sierra Club v. Morton case.

6.03 Full capacity pumping.

The existing Delta Pumping Plant has the capability to pump 4.56 million acre-feet per year, which theoretically could meet the State's full contractual obligation (4.23 million acre-feet annually). However, as a practical matter, meeting this level of diversion with present capacity would not be possible because of a highly variable water supply and the need for varying pumping rates to comply with applicable water quality standards and seasonal export limits for fishery protection. It would also greatly increase on-peak power requirements and thus, operating costs. Flexiility in pumping rates is essential if contractual obligations are to be met. Operation with the full planned pumping capacity would provide the needed flexibility. The state Department of Water Resources, therefore, has also applied for a Department of Army permit to expand the operational capacity of the Delta Pumping Plant from 6,300 cfs to 10,300 cfs by adding four pumps, and to increase, gradually, the level of exports consistant with the State's full contractual obligations. Increasing the amount of water exported through the Delta Complex to over four million acre-feet per year with an expanded pumping capacity would have significant impacts. Such impacts will be additional in a supplement to this EIS before any decision on the request to expand capacity is made.

6.04 DWR applied seperately to the Corps of Engineers for a permit for limited operation of four additional pumping units at the Delta

Pumping Plant. Although the capacity of the plant would be increased from 6,300 to 10,300 cfs, amount of water to be diverted under limited operation would be no greater than the amount of water which could be diverted under present conditions. The ǒbjective of this plan is economic and energy savings through increased pumping during off peak hours with no significant adverse effects to the Delta environment from the operation of the additional pumps.

6.05 Operation studies show that the additional four pumping units would enable a shift of pumping about 648,000 acre-feet of water per year from on-peak to off-peak hours under normal hydrology and tides. This increased use of off-peak energy would be environmentally beneficial in reducing demand variation for power suppliers and freeing existing capacities for other uses. There would also be an undermined savings in energy as well as capacity, since utilities run their more inefficient fossil fuel plants for peak demand periods. This shift from on-peak energy consumption at the Delta Pumping Plant would bve equivalent to a long-term net savings of at least 30 megawatts on-peak capacity and $3 million annually for the SWP system with an assumed rate of $100 per kilowatt year. Because of the reduction in peak power requirements and the related fiscal savings, DWR has found the four new pumps to be a viable additon to the SWP whether or not approval for greater diversions is received. The benefit-cost ration would be at least 2:1 with continued operation on this basis.

6.06 The proposal for expanded capacity and limited operation includes enlargement of he Delta Fish Protective facility. The design incorporates the following major features:

1. Activation of the three additional channels with installation of louvers and control gates.

2. Installation of dividing walls in one existing channel and one new channel.

3. Installation of new secondary channels with perforated plates.

4. Installation of new pumps for water recirculation.

5. Finer mesh screens in the holding tank system.

This work will cost about $2 million.

6.07 In summary, expanded capacity with limited diversions would have the following impacts: (22)

(a) Construction activities will be entirely within the existing plant. Transportation of materials and equipment to the plant may cause temporary delays to the public on lightly traveled county roads.

(b) Water quality conditions in the Southwestern Delta are affected by the export-outflow relationship, which will be maintained by upstream reservoir releases and/or reduced exports during low-flow periods. The proposed project would not significantly affect this relationship, nor water quality.

(c) The Delta channels near the Clifton Court intake are 9 to 20 feet deep. The drawdown (lowering of water levels) would be a maximum of about 0.1 feet greater under the proposed project than it would be with present pumping capacity. During extreme low tides drawdowns would be less than with the existing plant.

(d) No significant increase in scouring or siltation of nearby Delta channels is expected under the plan of operation. The expected maximum forebay inflow rate has been exceeded in previous tests without appreciable scour or siltation.

(e) Enlargement of the Fish Protective Facility would have an overall beneficial impact on fishery resources, particularly for striped bass.

(f) Operation with the additional units would increase the fluctuation of Clifton Court Forebay, but recreation at this reservoir would not be significantly affected.

(g) The additional pumping units would enable a shift of pumping about 648,000 acre-feet of water per year from on-peak to off-peak hours. This operation would enable the long-term peak power demand to be decreased by 30 megawatts. This reduction of on-peak consumption would free existing capacities for other uses.

6.08 Expanded capacity with limited diversions will be discussed further in the Supplemental Environment Statement for full operation.

6.09 Reduced Pumping Alternatives.

Reduced pumping of water otherwise available in the Delta would initially have minor to catastrophic adverse economic and financial impacts on the water users and in the State as a whole, depending upon the magnitude of pumping curtailments. The effects of any pumping curtailment would increase with time.

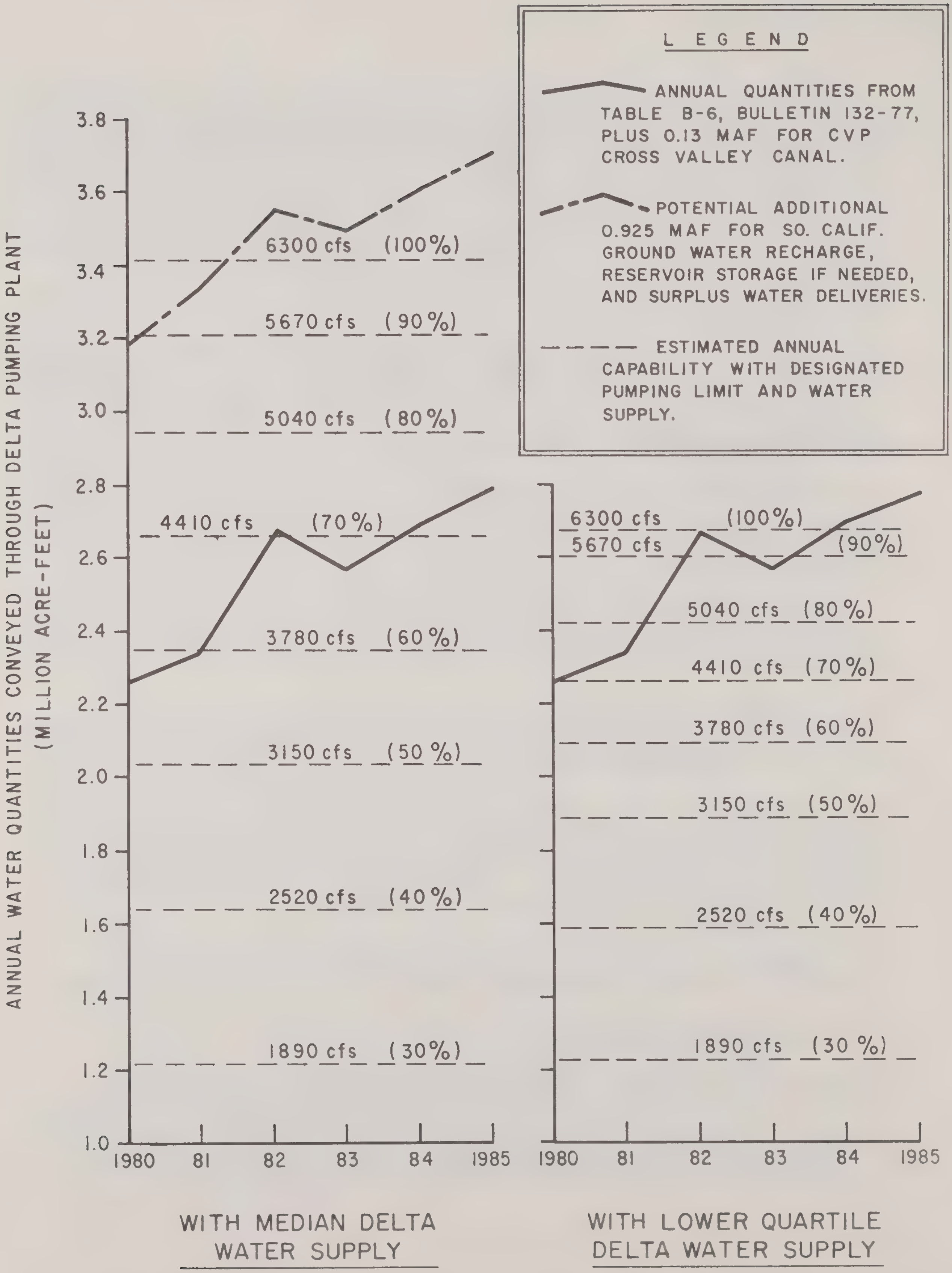


Figure 20 DELTA PUMPING PLANT - ESTIMATED PUMPING REQUIREMENTS AND CAPABILITIES

Figure 20 shows estimated annual pumping capabilities of the existing Delta Pumping Plant under various pumping limitations and with two water supply conditions in the Delta: median and lower quartile. The pumping limitations shown range from maximum average monthly rates of 6,300 cfs (full capacity) to 1,890 cfs (30 percent of capacity), in 10 percent intervals. The annual capabilities are the summation of monthly values, which were constrained either by the available water supply or the assumed pumping limit. Water supply is usually the governing factor from May through November. Water supply thus has a major effect on the capabilities. the monthly water supplies reflect pumping limits for striped bass protection in May, June, and July.

6.10 Figure 20 also shows (solid line) estimated annual pumping requirements from 1980 to 1985, as shown in Table B-6 of Bulletin 132-77*, plus an additional 0.13 MAF for CVP Cross Valley Canal deliveries. The upper line (dotted) shows an additional 0.925 MAF for Southern California groundwater recharge (75,000 acre-feet) and surplus water deliveries when water supply conditions permit. When this upper line is above any designated capability, the full potential cannot be met.

6.11 Pumping capabilities below the solid line represent curtailments, primarily for entitlement deliveries. Pumping capabilities above the solid line represent opportunities for additional reservoir storage if needed, for ground water recharge, and lastly for surplus water deliveries.

6.12 With a lower quartile water supply in the Delta, difficulties are expected in meeting the projected pumping requirements during the 1980-85 period and thereafter with existing facilities.

6.13 Moderate Reduction of Pumping:

Even a moderate limitation on pumping could adversely affect reservoir storage and the groundwater recharge program. For example, in the winter of 1977-78 DWR was refilling the depleted SWP reservoirs south of the Delta. Additional constraints on pumping would have effectively reduced the opportunities to restore storage to pre-drought levels and for groundwater recharge when the water supply conditions improved early in 1978.

6.14 For purposes of evaluating and comparing alternative operations during the 1980-85 period, the 70 percent pumping limit was selected as representative of a moderate pumping reduction. Although this

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* Table B-6 requirements include operational losses, reservoir storage charges, and deliveries for entitlement water and for recreation.

limitation trends toward a gradual curtailment of entitlement deliveries, as shown in Figure 20, it was not considered to adversely effect entitlements, reservoir storage, or SWP recreation in 1980. It could, however, significantly reduce or eliminate surplus water deliveries in 1980 and thereafter.

During the 1980-85 period, entitlement deficiencies would average about one percent annually with a median water supply and 12 percent annually with a lower-quartile water supply.

6.15 Severe Reduction of Pumping:

Pumping limitations lower than about 60 percent of capacity would adversely affect entitlement deliveries by 1980. The 30 percent limitation was selected as representative of a severe reduction of pumping during that year. Based on Figure 20, this would result in entitlement curtailments of about 800,000 acre-feet, or 40 percent of requested 1980 SWP deliveries south of the Delta. The remaining 60 percent was proportioned equally as follows for evaluating economic impacts in the service areas.1/

South Bay	81,700	acre-feet
San Joaquin Valley	461,600	acre-feet
Southern California	658,700	acre-feet
TOTAL	1,202,000	

Permanent curtailments of this magnitude could lead to pressure for withdrawals from reservoir storage. If storage was uniformly depleted to minimum operating levels over the 1980-85 period, entitlement curtailments in 1980 could then be reduced about 600,000 acre-feet or 30 percent. However, reservoir recreational use would then be sharply curtailed.

6.16 Impacts of reduced pumpøng on the SWP service areas:

a. South Bay Service Area. If pumping were restricted to 30 percent of plant capacity it would result in a reduction of the 1980 entitlements by about 53,000 acre-feet. It is assumed that the reduction would be distributed to the districts within the service area in the same proportion as the distribution of entitlements in

1/ Article 18b of the Standard Water Supply contract specifically provides, if for any reason there is a reduction in project yield which threatens a permanent shortage in project water supplies, annual entitlements of all contractors, except contractors with established rights under the area of origin statutes, shall be proportionally reduced to the extent necessary to comply with the storage.

that year. The impact of the reduction would be increased reliance on the groundwater supply, subsequent overdraft, degradation of the groundwater supply, land subsidence in Santa Clara County, and, in the southern portion of Alameda County, saltwater intrusion. A reduction in per capita usage would be less severe if conservation and rationing were imposed. However, in each district there would eventually be a need to locate alternative supplies to meet the demand anticipated from population increases and increased employment.

b. San Joaquin Service Area. If pumping is limited to 30 percent of capacity, SWP deliveries to the San Joaquin Valley service would be reduced to slightly 5 percent above deliveries in 1977, a year when SWP pumping was severely curtailed due to extreme drought conditions. Farmers responded to the limited water supply by significantly reducing field and truck crop acreages.

Assuming that growers respond to reduced water availability in 1980 as they did in 1977, value of production is projected to decrease from $156 million to $110 million. Direct and indirect income impacts are projected to decrease from $245 million to about $165 million, $80 million less than with full entitlements. Direct and indirect employment impacts are projected to be about 8,800 jobs, or about 80 percent of employment attributable to full pumping capacity.

c. Southern California Service Area. If the Delta Pumping Plant were limited to 30 percent of pumping capacity, deliveries to the Southern California service area would be approximately 600,000 acre-feet less than 1980 entitlements.

With the exception of MWD, such a reduction to the contracting agencies in the Southern california service area would not place a severe constraint on available water supplies (less than ten percent of the total), although water quality may be affected.

The MWD constituent agencies and districts, however, would be noticably affected by a cutback in SWP water. Nearly 400,000 acre-feet would have to be supplied from other sources to meet the projected demand for 1980. MWD could pursue the following to obtain the required amount of water:

- Increase the importation of Colorado River water until at least 1985, at which time MWD's allotment would have to be reduced due to the anticipated initial operation of the Central Arizona Project.

- Purchase some additional water from the City of Los Angeles Department of Water and Power, which is transported from Owens Valley.

- Increase wastewater reclamation.

- Cutback water allotment to constituents.

- Pursue other long-range measures such as obtaining additional water sources outside of the Southern California Service area and desalinization of sea water.

6.17 Cease Pumping.

If pumping were completely stopped there could be no further SWP deliveries south of the Delta without withdrawals from storage. If reservoir storage were depleted to minimum operating levels in 1980, only about one million acre-feet could be delivered that year. CVP deliveries via the Cross Valley Canal would also be stopped, or greatly curtailed.

The magnitude of the curtilments of SWP recreation due to stopping operations at the Delta Pumping Plant, and subsequent depletion of reservoir storage, was estimated in 1974 over the period 1975-80. The results are summarized below:

Condition	Estimated Recreation Use (Million Recreation Days) 1975	1980	Percent Loss in 1980
Continue Operations As Planned	3.57	8.26	0
Cease Pumping, Deplete Reservoir Storage to Minimum Operating Levels, Mainly in 1975	2.26	3.61	-56%

Similar estimates for the 1980-85 period would show an even greater loss because of increasing recreation use projections.

6.18 Impacts of ceased pumping on SWP Service Areas:

a. South Bay Service Area. Under a cease pumping alternative, the water districts in the South Bay service area would rely on groundwater pumping to supplement their water supply in 1980 and thereafter. In the Santa Clara Water District there would be an annual deficit of 88,000 acre-feet. If this amount were pumped from groundwater it would result in degraded groundwater quality and subsidence, and may also induce massive saltwater intrusion. Before subsidence was stopped an average of 100 wells per year were damaged and had to be replaced or repaired at an estimted average annual cost of $600,000. If SWP water, or a similar supply, were not available, it would be necessary to construct a levee system to prevent

subsidence in the Santa Clara Valley Water Basin at an estimated cost in 1971 of $54 million.

Alameda County Water District, Zone 7 would rely on ground water to supply the deficit in anticipated 1980 demand. Poor water quality is a problem with a high content of total dissolved solids (280 mg/l), chloride, and boron. Over the long run the district would be unable to meet the anticipated water demand, unless alternative water resources were located. The Alameda County Water District would also have to rely on groundwater pumping and it is expected that there would be a depletion of the groundwater supply, saltwater intrusion, and a degradation of the water quality.

b. San Joaquin Valley Service Area. In the short run, the most likely scenario in the event of cease pumping would be a reduction in net farm production profits, while large areas of farm land would be taken out of production.

In order to minimize losses, the following actions might be taken:

- Increase groundwater pumping.
- Divert water from municipal and industrial contractors in Southern California.
- Take conservation measures to increase irrigation efficiency, beyong those already being undertaken.
- Plant less water-intensive crops.
- Reduce acreage planted.

One of the major objectives of the State Water Project is to reduce existing groundwater overdrafts. The groundwater overdraft would be intensified without SWP water. If the deficit could be compensated for by groundwater pumping, an additional 765,000 acre-feet of groundwater could be needed. The current cost of electricity to pump this amount is estimated to be at least $6 million. Increased potential of well collapses, ground subsidence, anddecrease in water quality would occur. Small growers may be forced out of business due to high capital costs of drilling -- up to $150,000 for a single well.

During the 1977 drought year, reduced SWP water deliveries were somewhat offset by diversion of water from M&I contractors in Southern California. In 1980, it is anticipated that Southern California contractors would be more reluctant to release water for San Joaquin Valley use due to impending curtailment of Colorado River water diverted to the Central Arizona Project.

Conservation measures to increase irrigation efficiency require increased investment in both capital and labor, reducing net profits to growers. Also, with the present basin wide water use efficiency in the Tulare Lake Basin (currently the highest in the state), conservation measures do not appear very promising, particularly in view of the salt balance problems. Planting of less water-intensive crops would presumably have the same effect of reducing net profits, since profit maximizing growers would have fewer opportunities to grow the most profitable crops.

Districts with no alternative water supply have over 45,000 acres in trees and vine crops and over 115,000 acres in annual crops. If these districts were to go out of production, private investment losses of over $46 million for annual crops and $90 million for tree and vine crops are projected.

Retirement of agricultural lands because of curtailed water supplies would eliminate a portion of suspended particulate matter caused by agricultural tilling and burning. This would be offset by increased wind erosion from the retired agricultural lands.

c. Southern California Service Area. If SWP water were no longer available, the greatest impact would be on the MWD constituent agencies, which expect to import 882,000 acre-feet, 21 percent of the total water demand. Other districts receiving state water would probably either have to cut back total use through water conservation and curtailment, or increase non-state water sources. MWD, however, would have to make drastic changes in its projected 1980 water budget. A number of actions could occur that would aid in meeting the demand for 882,000 acre-feet.

- Increase the importation of Colorado River water from a projected 867,000 acre-feet i=to the maximum entitlement of 1.2 million acre-feet (a gain of 333,000 acre-feet, and only possible until Colorado River water is diverted to the Central Arozona project).

- Purchase additional water from the City of Los Angeles' Owens Valley Aqueduct (maximum possible is aout 90,000 acre-feet; even this is unlikely due to current litigation and continued growth).

- Increase production of wastwater reclamation (amount unknown, but costs for water quality treatment in wastewater reclamation would dramatically increase with poorer quality water).

- Cut back water allotment by 10 to 20 percent (a reduction of 88,000 to 176,000 acre-feet).

- Vigorously enforce water conservation practices (amount unknown but the experience of some Northern California counties during the 1976-1977 drought showed that a reduction of up to 50 percent or more in household consumption was possible under emergency conditions).

- Develop new aqueducts, channels, etc., to import new water (locations and amounts unknown).

- Pursue remote possibilities, such as desalinization of sea water with use of nuclear power or other treatment processes (current estimates for the cost of desalinization run from $750 to $1,000 per acre-foot which appears to be prohibitive until the technology can be made more cost-effective).

The cessation of SWP water would cause an increase of 200 to 300 mg/liter TDS or more in the water quality of those areas in Southern California that depended on SWP water to enhance the quality of water for municipal and industrial use. Such an increase would have the following adverse effects:

- An increase of $22 to $34 million to households, in the costs for soaps, detergents, cleansing agents, maintenance, and replacement of water heaters, water-related appliances, and plumbing fixtures.

- An increase in the cost to industries for treat water.

- An increase in the cost of municipal treatment and water distribution systems and the reactivation of water softening facilities.

- An increase in the use of water softeners for individual households as well as laundries, restaurants, institutions, hospitals, etc.

- An increase in the cost for wastewater reclamation.

- Possible violation of the water quality control plans for groundwater basins developed by the State Water Resources Control Board.

The changes in land use, population, and economic growth probably would not be directly affected by the cessation of SWP water, although most sectors of the economy could be affected to some extent by the increased costs caused by higher TDS in the water.

State and Local Financial Effects of Reduced Pumping Alternatives.

6.19 With continued operations as proposed, water sale revenues would enable continuation of payments to the State and for debt service on local facilities for use of SWP supplies. The present bonded indebtedness for such facilities exceeds $0.8 billion. With the 70 percent pumping limitation, water sale revenues would be reduced during the 1980-85 period and frozen thereafter. Many local facilities would then be oversized. Tax increases or increased water charges would be necessary. The financial impact would vary from district to district and some might default on State payments.

6.20 With the 30 percent limitation, the local financial impacts would be considerably more severe. Under the cease pumping alternative there would be no water sale revenues, the local facilities would be useless, and about a $136 million in private investment would be lost in the San Joaquin Service area.

6.21 Under the proposed operation, the debt service on State water bonds continues to be repaid from water sale revenues and the State's high credit position is maintained. With the reduced pumping alternatives, the debt service payments would be severely reduced or eliminated, general fund monies would be needed for repayment of the water bonds, and the State's credit position would be weakened. These statewide financial impacts become progressively worse with greater pumping limitations.

The Effects of Reduced Pumping on Fish and Wildlife in the Sacramento-San Joaquin Estuary.

6.22 The reduced pumping alternatives would improve conditions for the Delta Fishery and for wildlife in the Suisun Marsh. The cease pumping alternative (the base condition assumed for evaluating water quality and fish and wildlife impacts of the proposed operation) would be the most beneficial. Conditions under this alternative were previously shown. The 70 percent and 30 percent pumping limitations would generally provide intermediate conditions for fish and wildlife. However, interpretation of pumping levels would be of questionsable accuracy. Model studies were not made for these intermediate levels, thus prohibiting comparable evaluations.

6.23 However, abundance indices at intermediate levels were estimated for striped bass and for Neomysis. These estimates are shown below, along with those for the proposed operation and the cease pumping alternative.

Cease	Year	Proposed Operation	70% Limit	30% Limit	Cease Pumping
Estimated Striped bass	Crit. Dry	48	55	62	70
	Above				
Abundance	Normal	88	93	93	104
Indice (Total for Delta and Suisun Bay)	Wet	111	119	126	135
Estimated *Neomysis*	Crit. Dry	1.1 (5)	3.3 (5-45)	4.6 (25-45)	4.8 (25-45)
Abundance indice (x 10^{10}) with designated concentration in parenthesis (ug/l)	Above Norm.	4.7 (25-45)	5.0 (25-45)	5.2 (25-45)	5.0 (25-45)
	wet	4.6 (5-35)	3.8 (5-15)	4.3 (5-14)	5.6 (15-25)

6.24 The numbers of fish exposed to the fish facility would be decreased with the reduced pumping alternatives. However, the magnitude of this reduction is unknown. Annual fish screen efficiencies for the existing pumping plant and fish facility were previously shown. For the cease pumping alternative, the facility would not be operating and efficiencies would not be applicable. Estimates were made for the intermediate pumping levels. However, they were necessarily based upon questionable assumptions about operating procedures and yielded inconsistent results, which are not shown here.

6.25 Energy impacts of Reduced Pumping:

Estimated annual energy requirements for the Delta Pumping Plant under the alternatives considered are shown below (values in millon Kwh):

Year	Proposed Operation	70% Limit	30% Limit	Cease Pumping
Critically Dry	667	667	393	None
Wet	1,007	923	419	None

The reduced pumping alternatives would also decrease energy and capacity requirements for the entire aqueduct system.

6.26 Diversion of Suspended Sediment:

Estimated wet year diversions of suspended sediment under the alternatives considered are shown below (values in 1,000 tons):

Proposed Operation	70% Limit	30% Limit	Cease Pumping
327	281	93	None

6.27 Aqueduct System Fishery:

The effect of reduced pumping alternatives upon the fishery in the SWP aqueducts and reservoirs cannot be estimated. Other major factors effecting the system fishery under reduced pumping alternatives are the status of CVP pumping and the operational levels of the major reservoirs. In any event it is questionable that the aqueduct fishery could be sustained at present levels with a severe reduction of pumping.

7.00 THE RELATIONSHIP BETWEEN SHORT-TERM AND LONG-TERM PRODUCTIVITY

7.01 The past construction of the Delta Complex facilities, together with the entire SWP aqueduct system, has resulted in land use changes and decreases in the long-term productivity of lands now occupied by these facilities. Past operation of these facilities has provided irrigating farmers a means to increase and diversify their agricultural productivity. Past operation has also supported normal urban growth in the SWP service areas, and has alleviated ground water overdraft problems.

7.02 Continued operation is essential to maintenance of established agricultural productivity, and for planned increases in the beneficial uses of water in the SWP service areas.

7.03 Continued operation would contribute to a reduction of annual biological productivity in the Sacramento-San Joaquin Estuary. To the extent these losses occur, they can be considered a long-term resource commitment. The SWP diversions are one of several man-made and natural factors affecting biological productivity in the Estuary. Fish and Wildlife productivity has historically rebounded from losses suffered in drought periods.

7.04 Continued operation as planned will require increasing quantities of energy and construction of new generating facilities. To the extent that construction of generating facilities using non-renewable fuels can be deferred, the option remains of considering renewable sources of energy that may become available at a date.

8.00 IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES INVOLVED WITH PROJECT OPERATION

8.01 In varying degrees of irreversibility, commitments of resources for the SWP have already been made. The approval of a permit for operation of the Delta Pumping Plant and Clifton Court Forebay would not in itself constitute any further irreversible commitments of resources. An operating permit could be modified or revoked upon a determination that such a course of action is in the public interest.

8.02 A substantial commitment of resources was involved in the construction of the existing SWP facilities. Such resources consisted of capital funds, lands, material, and labor. These commitments were irreversible. Additional expenditures are needed to operate and maintain these facilities.

A permit for operation of the Delta Pumping Plant would not affect these previous commitments.

8.03 Water rights for water to be conveyed by the Delta Pumping Plant relate to the SWP systems. While the granting of water rights permits may be considered irreversible, the conditions attached to the permits for Delta protection have been modified in the past and may well be modified in the future.

8.04 Commitments have been made in water service contracts by the State Government to deliver water of a specified quantity and quality throught the SWP conveyance facilities. The State water contractors have committed hundreds of millions of dollars under water service contracts and for necessary local facilities with the full expectation that the project will fulfill their obligations.

8.05 Under the water service contracts, and with existing facilities, there is some flexibility in the operation of the Delta Pumping Plant and the diversions from the Delta over any period of time. Also, the water service contracts could be modified during emergencies, as was done in 1977 in changing the place of use of the water from Southern California to Marin County, the San Joaquin Valley, and other areas.

8.06 Contracts for purchases of power for the SWP constitute a commitment for the use of energy resources. Such contracts are related to the water service contracts.

8.07 The additional facilities proposed in the Delta Alternatives Program would increase the capability and the flexibility for both Delta protection and meeting of the obligations under the water service contracts. An operating permit for the Delta Pumping Plant would not in itself constitute a commitment to building these projects.

9.00 COORDINATION

9.01 Delta Complex operation has been extensively coordinated with other agencies and the public since its beginning. The main agencies involved have been the Bureau of Reclamation, the Fish & Wildlife Service, the Department of Fish & Game, and the State Water Resources Control Board. Results from this coordination hab been discussed previously in this environmental statement in the section describing statues, agreements and programs related to operation of the Delta complex; for example; Basin Plans, Four Agency Fish Agreement, the Ecological Study Program, the Long Range Energy Program, abd CVP-SWP coordinated operation. DWR has, in addition, published annual bulletins (18) that describe the State Water Project's operation for the previous year and discuss the future management plans.

9.02 Preparation of this draft environmental statement required much coordination between DWR and the Corps of Engineers. The draft environmental statement will be coordinated with those agencies groups and individuals listed in the Summary of this environmental statement, page V.

GLOSSARY OF TERMS

Above Normal Year. A year when the total unimpaired runoff at four Sacramento Valley locations is between 15.7 and 19.6 MAF, or 22.5 MAF when preceding year is critical. See "Water Year Classification".
Abundance Index. As used in this report, a number representing the estimated totalpopulation of a given species existing under certain conditions in the Sacramento-San Joaquin Estuary relative to those existing under historic conditions (1922-67), See "Historical Levels".

Acre-foot. A volume of water measured as the amount needed to cover an acre to a depth of one foot. (43,560 cubic feet or 325,900 gallons).

Aeration. The process of adding to a body of water.

Algae. Small plants that grow in sunlit water that contains phosphates, nitrates, and other nutrients. Algae are food for small aquatic animals and, like all plants, add oxygen to the water. They are important in the fish-food chain in some instances.

Amphipods. A small crustacean related to shrimp. Those discussed are usually considered a benthos.

Anadromous. Of fishes, like the salmon and striped bass, that migrate from the sea to spawn in fresh water.

Aqueduct. A conduit, usually of considerable size, used to convey water. The conduit may consist of one or more of the following: canal, pipeline, flume, tunnel, siphon, and pumping and power plants.

Benthos. The whole assemblage of plants or animals living on the bottom of a body of water such as a lake, river, or estuary.

BOD (Biochemical Oxygen Demand). The quantity of oxygen needed in the biochemical oxydation of organic matter in a specified time, at a specified temperature, and under specified conditions.

Brackish. Somewhat saline, yet less so than sea water.

Capacity. (1) Capacity is the capability of a generation plant, or system of plants, to produce energy at any time. Capacity is usually expressed in kilowatts or megawatts. In this report, the term is used to denote the highest energy requirement for the California Aqueduct system during on-peak hours.

(2) The term is also used to quantify the capability of a facility to convey water. These values are in cfs. Centrifugal Pumps. Pumps lifting water by centrifugal force, the dominant type used in waterworks.

CEQA. California Environmental Quality Act (CEQA) set off in California Public Resources Code Sections 21000 et seq.

Check structures. Structures designed to raise or control the water surface in a waterway.

Chloride. A compound of chlorine with another element (or radical) to form a salt; an important constituent in sea water.

Chlorophyll. The constituent responsible for the green color of plants. Chlorophyll is essential for the production of carbohydrates by photosynthesis.

Chlorophyll-A. The most abundant form of chlorophyll.

Coliform-group bacteria. A group of bacteria most commonly found in animal and human wastes; thus the abundant presence of these organisms in in a body of water is used as an indicator that the water may not be suitable for human contact or consumption.

Corophium. A member of the Amphipod group.

Critical Year. A year when the total unimpaired runoff at four Sacramento Valley locations is less than 10.2 MAF, or 12.5 MAF when preceding year is critical. See "Water Year Classification".

Crustacea. Mostly aquatic arthropods, segmented animals with shells and paired jointed legs that breathe by means of gills and having no internal skeleton.

Cubic-foot per second (cfs). A unit of measure of the rate of liquid flow past a given point equal to one cubic-foot in one second. Also called second foot.

CVP. Federal Central Valley Project.

Daphnia. A crustacean zooplankter; belongs to the Order Cladocera and is also related to the Amphipods. Common name is "water flea".

Delta.

1. An alluvial deposit, often in the shape of the Greek letter "delta". whence it derives its name, which is formed where a stream drops its debris on entering a body of quieter water.

2. The Sacramento-San Joaquin Delta, as defined in Section 12220 of the California Water Code on November 8, 1960.

Delta Environmental Advisory Committee (DEAC). A committee formed in 1973 by invitation of the Director of Water Resources to help DWR

improve its understanding of environmental concerns related to water development and the Delta. DEAC is comprised of 12 members from various environmental groups and a consultant.

Delta outflow. In this report, the net flow from the Delta to the San Francisco Bay as computed at Chipps Island.

Detritus. Organic debris carried by streams as contrasted to inorganic sediment.

Diatom. A unicellular, microscopic aquatic organism with a box-like structure consisting principally of silica. They constitute the most abundant group of phytoplankton (algae) in the Delta estuary.

Dispersion. Spreading or mixing of a mass in a fluid by a physical action such as tidal mixing.

Dissolved oxygen. The oxygen dissolved in water, waste water, or other liquid, usually expressed in milligrams per liter, parts per million, or percent of saturation. Abbreviated DO.

DWR. California Department of Water Resources.

Dynamic computer model. A computer program that defines changing conditions with respect to an independent variable such as time.

Ebb tide. Tide occurring at the ebb period of tidal flow. Sometimes called falling tide to describe direction of current toward the sea.

EC -- electrical conductivity. A physical quantity that measures the readiness with which a medium transmits electricity. Commonly used for expressing the salinity of irrigation waters and soil extracts because it can be directly related to salt concentration. It is expressed in mnos per centimeter (or milliomhos per centimeter or micromhos per centimeter at 25 C). Can be correlated to ppm TDS, Cl, etc., for a particular location on a stream.

Ecology. The branch of biology dealing with the relationships between living organisms and their environment.

Effluent. Waste water or other liquid, partially or completely treated, or in its natural state, flowing out of a reservoir, basin, treatment plant, or industrial treatment plant.

EIR -- Environmental Impact Report. A detailed statement setting forth the environmental effects and considerations pertaining to a project as specified in Section 21100 of the California Environmental Quality Act.

EIS -- Environmental Impact Statement. An environmental impact report prepared pursuant to the National Environmental Policy Act (NEPA).

Embankment. An earth mound or bank raised to hold back water, support a roadway, etc.

Energy. As used in this report, energy is work measured in electrical units as kilowatthours, required to transport water by the Delta Pumping Plant. Electrical units are used throughout this report since all project pumping plants are electric and all project generation presently consists of hydroelectric plants. The demand (kilowatts or megawatts) for energy hour-byhour can vary over a wide range due to the wide flexibility in operation of the Project.

Energy Resource. As used in this report, energy resources are natural resources such as oil, natural gas, coal, uranium, geothermal system solar or wind.

Energy Sources. As used in this report, energy source refers to any source of electric energy including existing and future Project generating facilities, generating facilities owned by other utilities, or energy purchased under contract for Project use.

Energy Supply Arrangements. This term refers to that combination of energy sources including Project generation, purchase of energy from others, and any other source of energy, which collectively provide for Project energy needs through contracts for the sale, purchase, exchange and transmission of energy for the Project. The existing, or 1966-67 energy supply arrangements provide an assured supply of energy for project needs through March 31, 1983.

Entomostracan. Designating a subclass of crustaceans, including the branchipods, copepods, etc.

Enviroment. The complex of climatic, edaphic (relating to soils), aquatic, and biotic factors that act upon an organism or an ecological community and ultimately determine its form and survival; the aggregate of social and cultural conditions that influence the life of an individual or community.

Escapement (fish). Fish (generally anadromous) that are not caught by commerical or sport fishermen and are, therefore, available for spawning.

Estuary. The lower extremity of a river entering the sea that is subject to tidal action. The "Sacramento-San Joaquin Estuary" is defined as the legal Delta (Section 12220 of the California Water Code) and the bays and adjacent tidal waters westerly of the Delta to the Golden Gate.

Fishery. The activity (commerical or recreational) of catching fish or other aquatic animals. Also, the various species, abundance, and productivity of fish in a body of water.

Fish facilities. All physical works constructed and operated to preclude fish from entering a water diversion.

Fish screen. A barrier designed to pass water but to prevent fish from entering an artificial channel. Also, guidance devices such as a series of louvers are sometimes referred to as fish screens.

Fish screen efficiency. As used in this report, the proportion of the fish approaching the fish screen which are diverted into the holding tanks.

Floodtide. A term used for rising tide or landward current. Technically, flood refers to current.

Forebay. A reservoir or pond at the intake of a pumping plant or power plant used to stabilize water levels.

Fry. Very young fish. Ground water. Water beneath the earth's surface, accumulating as a result of seepage, and serving as the source of springs, wells, etc.

Ground water overdraft. A condition where the amount of water withdrawn by pumping exceeds the amount of water replenishment over a period of time.

Ground water recharge or replenishment. Increases in ground water storage by natural conditions or through the activities of man.

Ground water table. The upper surface of the zone of saturation (all pores of subsoil filled with water), except where that surface is formed by an impermeable body.

Head. The difference in elevation between two levels of water.

Historical levels. As defined in the draft Memorandum of Agreement, "historical levels" means the "Average Abundance" of "Adult Populations" estimated to have existed in the Estuary between 1922 and 1967. ("Average Abundance" is the arithmetic mean of the number of organisms estimated to have been present annually during the period. "Adult Population" is the number of a given species, or group of species, longer than the minimum legal length, or sexually mature).

Invertebrates. Animals lacking a spinal column.

Larvae. The early form of a fish, usually while it still has a portion of the egg yolk sac attached.

Leaching. The flushing of salts from the soil by the downward percolation of water. Usaully done by flooding the surface of the field.

Levee. An earth dike or embankment, generally constructed on or parallel to the banks of a stream, lake, or other body of water, intended to protect the landside from inundation by flood or tide waters or to confine the streamflow to its regular channel.

Long-range. With reference to DWR's Long-Range Energy Program, Long-Range refers to "life of project". Since the 1966-67 energy supply arrangements provide for project energy needs until April 1, 1983, the long-term period begins in 1983 and extends for the life of the SWP.

Lower-quartile water supply. That water supply determined to be equalled or exceeded 75 percent of the time from a long-term operation study. Lower-quartile supplies are drier than normal but are not considered critically dry. DWR uses monthly lower-quartile water supplies (in the Delta available for SWP export) for many operation studies. Median water supplies (those equalled or exceeded 50 percent of the time) are also used.

Louver. An opening provided with one or more slanted fixed or moveable fins to allow flow of water, but, in the case of fish screens, to exclude fish.

Mathematical models. A sequence or system of equations that mathematically define a real situtation, reaction, or process.

MAF. Million acre-feet.

M&I. Municipal and Industrial.

Mean tide. The average water surface elevation of a body of water affected by tides.

Mysid. A group of shrimp-like aquatic animals (Neomysis). Natural runoff. The flow of a stream as it occurs under natural, as opposed to regulated conditions.

Natural runoff. The flow of a stream as it occurs under natural, as opposed to regulated conditions.

Navigable waters. Waters of the United States that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible to use to transport interstate or

foreign commerce. The Corps of Engineers administers certain laws pertaining to protection and preservation of navigable waters. This regulatory function includes a permit program for many activities in navigable waters.

Neomysis. A member of the shrimp-like mysid group. A principal food supply of young striped bass, and other fish.

NEPA. National Environmental Policy Act.

Net flow. The resulting average flow in a given direction during a tidal cycle.

Nutrient. Something that nourishes; food.

Off-peak. Off-peak refers to the time of day and week when use of energy in the region is at a minimum. As provided in the Suppliers Contract and as used in this report, the off-peak hours are between midnight and 7 a.m. and between 10 p.m. and midnight on Monday through Friday, between midnight and 1 p.m. and between 10 p.m. and midnight on Saturday and all day on Sunday (All times are Pacific Standard Time.). The term "on-peak" refers to the remaining hours of the week.

Oxidant standard. One of the air quality standards established by the State Air Resources Board or by the Federal Environmental Protection Agency. Oxidant is a collective term given to some of the gases formed as a result of photochemical action in the atmosphere. It is a mixture of mainly ozone, with small quantities of nitrogen dioxide and peroxyacetylnitrate (PAN). The Federal Air Quality Standard for oxidant is 0.08 ppm for 1 hour.

Parts per million (ppm). The number of weight or volume units of a minor constituent present with each one million units of the major constituent of a solution or mixture, such as salts in water.

Photosynthesis. The process of conversion, by plants, of water and carbon dioxide into carbohydrates under the action of light. In photosynthesis Chlorophyll is required for the conversion of the light energy into chemical forms.

Phytoplankton. Small plants, usually microscopic in size, which float in the water and drift with the currents.

Plankton. The marine animal and plant organisms that drift or float with currents, waves, etc., unable to influence their own course, ranging in size from microorganisms to jellyfish.

Pollution. In a general sense as used in this report, a condition created by the presence of harmful or objectionable material in water. Legal definition is contained in Section 13050 of the Water Code.

Pollution block. Primarily a barrier to migrating fish caused by low dissolved oxygen as a result of pollution.

Project water. As used in this report, water made available for all planned uses by project conservation and transportation facilities of the State Water Project.

Reclaim. To bring an area (e.g., swamp) into a condition to support cultivation or life, by building levees and draining.

Reclaimed water. Water that, as a result of treatment of wastes, is suitable for a direct beneficial use or a controlled use that would not otherwise occur. (California Water Code, Section 13050.)

Recreation-day. A measure of recreation use by one person for one day or part of a day. It may be as brief as an hour or it may be as long as 24 hours.

Resident fish. A fish that spends its life in one general location without migration.

Reverse flow. Flow in a direction opposite to the normal flow -- sometimes referred to as negative or upstream flow.

Right-of-way. The land occupied by public works such as roads, canals, etc.

Riparian. Of or on the banks of a stream or other body of water.

Run (fish). The migration of anadromous fish, usually within a certain period of time.

Runoff. The surface flow of water from an area; or the total volume of surface flow during a specified time.

Salinity. Generally refers to the concentration of mineral salts dissolved in water. Salinity may be measured by weight (TDS), electrical conductivity (EC), or osmotic pressure (ATM). Where sea water is known to be the major source of salt, salinity is often used to refer to the concentration of chlorides in the water.

Salinity intrusion. The invasion of a body of fresh water by a body of salt water. It can occur in either surface or ground-water bodies.

Salts. The minerals which water picks up as it passes through the air, over and underground, and through municipal, industrial, agricultural, and other uses.

San Francisco Bay complex. The contiguous bays west of and including Suisun Bay.

Sediment. Mineral or organic solid material that is being transported from its site of origin by streamflow. Smaller particles of sediment are suspended in the water as they are transported; heavier particles are moved along the bottom by the force of the current.

Sedimentation. The processes of erosion, transport, and deposition of sediment.

Silicate. Major nutrient for diatoms (algae).

Silt. A granular soil which is finer than sand yet coarser than clay.

Slough. A tideland or bottomland creek. A side channel or inlet, as from a river or bayou; may be connected at one or both ends to a parent body of water.

Spawning. The deposit of eggs (or roe) by fishes.

Surface zone salinity. The salt concentration at or near the surface of a body of water.

Surplus water.

1. A general term that refers to water not used for the reasonable and beneficial needs of the areas where it orginates. Since the amount of water flowing into the Delta varies greatly from year-to-year, month-to-month, and even for shorter periods, the amount of surplus water varies at any given time.

2. In connection with the surplus water program under the SWP contracts, to reduce the overall cost of water to agricultural contractors during the early years of entitlement buildup. Surplus water is now defined as water that can be delivered without interfering with annual entitlements and the needs for other project purposes.

SWP. California State Water Project.

SWRCB. State Water Resources Control Board.

TDS. Total dissolved solids. A quantitative measure of the residual of minerals dissolved in water that remain after evaporation of a solution; salinity. (Usually expressed in parts per million or milligrams per liter.)

Tidal cycle. In the San Francisco Bay estuary, two high and two low tides over one lunar day of about 24.8 hours.

Tidal marsh. Low, flat marshlands traversed by interlacing channels and tidal sloughs and usually inundated by tides. Usually applied to marshlands subjected to brackish or salt water.

Tidal Prism. The total amount of water that flows into a tidal basin or estuary and out again with movement of the tide, excluding any freshwater inflow.

Trap Efficiency. The amount of sediment retained in a sediment basin or reservoir, expressed as a percentage of the inflowing amounts.

Trash rack. A grid or screen placed across a waterway to catch or fend off floating debris.

Tributary. A stream or other body of water, surface or underground, that contributes its water to another and larger stream or body of water.

Turbidity. A condition in water caused by the presence of suspended matter, resulting in the scattering and absorption of light rays.

USBR. U.S. Bureau of Reclamation, the agency responsible for planning, construction, and operation of the CVP and many other water projects in the western United States.

Unimpaired runoff. That runoff which would occur under natural conditions, unaltered by upstream diversions, storage, or by export or import to or from other watersheds.

Water Year Classification. The draft Memorandum of Understanding classifies years based on forecasted unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year), as appearing in DWR Bulletin 120 "Water Conditions in California". Year classifications are based on the sum of forecasted unimpaired runoff for the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; and American River, total inflow to Folsom Reservoir.

Runoff values for the five classifications are:

- Wet year = _ 19.6 MAF or _ 22.5 MAF when preceding year is critical
- Above normal year = _ 15.7 MAF
- Below normal year = _ 15.7 MAF
- Dry year = _ 12.5 MAF or _ 15.7 MAF when preceding year is critical
- Critical year = _ 10.2 MAF or _ 12.5 MAF when preceding year is critical

In addition to the year classifications enumerated above, a subnormal snowmelt year classification is established based on forecasted April through July unimpaired runoff at the same four Sacramento Valley locations listed above. Any otherwise wet, above normal, or below normal year will be designated as a subnormal snowmelt year whenever the

forecasted April through July unimpaired runoff reported in the May issue of Bulletin No. 120 is less than 5.3 MAF.

Waste water. The used water, liquid waste, and drainage of a community, industry, or institution.

Waste water reclamation. The process of treating waste water to produce water for beneficial uses, its transportation to the place of use and its actual use.

Wet year. A year when the total unimpaired runoff at four Sacramento Valley locations is equal to or greater than 19.6 MAF, or 22.5 MAF when the preceding year is critical. See "Water Year Classification".

Zoobenthos. Animal organisms living on the bottom of water bodies.

Zooplankter. A particular species of zooplankton.

Zooplankton. Animal microorganisms that drift with the current water. They include small crustacea, such as daphnia and cyclops, and single-cell animals as protozoa, etc.

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PROJECT DESCRIPTION

DELTA PUMPING PLANT, INTAKE CHANNEL AND CLIFTON COURT FOREBAY

Location

The Delta Pumping Plant, Intake Channel and Clifton Court Forebay are located at the south edge of the Delta approximately 12 miles northwest of Tracy, California, at the Contra Costa-Alameda County line.

Purpose

The Delta Pumping Plant, Intake Channel and Clifton Court Forebay divert water from the Sacramento-San Joaquin Delta to the California Aqueduct, part of the State Water Project, for beneficial use in the San Joaquin Valley, South San Francisco Bay, Central Coastal and Southern California areas of need. The Clifton Court Forebay inlet control structure diverts water from the Sacramento-San Joaquin Delta into the forebay. The Delta Pumping Plant pumps the water from Clifton Court Forebay into the California Aqueduct. This water is entirely contracted for by local water vending agencies.

Engineering Plan

Water in the Sacramento-San Joaquin Delta waterways are diverted into Clifton Court Forebay, thence are drawn through a fish protective facility and are conveyed in the intake channel to the Delta Pumping Plant. The pumping plant lifts the water from the intake channel to the California Aqueduct.

Facilities

Clifton Court Forebay

The inlet for the forebay was constructed under Department of the Army Permit No. 4101, dated June 15, 1967. The forebay is located in Contra Costa County and occupies most of the Clifton Court Tract. At maximum water surface elevation of five feet above mean sea level, USGS datum, the forebay has a surface area of 2,109 acres, a shoreline length of 8 miles, and a storage capacity of 28,653 acre-feet. The inlet is at the southeast corner of the forebay and taps West Canal near its southern junction with Old River. Diversions through the inlet are controlled by five 20-foot wide by 25.4-foot high radial gates which are opened during high tides and closed during low tides. Water is then withdrawn from the forebay into the pumping plant intake channel through an outlet on the west side of the forebay. This outlet is uncontrolled and the flow rate is regulated by the Delta Pumping Plant pumpage.

Clifton Court Forebay provides hydraulic flexibility for operation of the Delta Pumping Plant — (1) it accommodates mismatches between the rate of inflow from the Delta and the pump draft, (2) it permits maximum use of off-peak power for pumping by drawing on the forebay water storage, and (3) it avoids the withdrawal of Delta waters during low tides.

Delta Pumping Plant Intake Channel

This 2.7 mile long waterway connecting Clifton Court Forebay to the Delta Pumping Plant is an unlined canal except for some rock slope protection. It is designed to convey 10,300 cubic feet per second at a flow depth of 38 to 42 feet. It has a trapezoidal section — 60 to 80-foot base width, 42 to 46 feet deep and 1.75:1 to 3:1 side slopes.

A fish protective facility and collection works are constructed near the beginning of the intake channel to divert and retrieve fish for return to the Delta waterways.

Delta Pumping Plant

The Delta Pumping Plant is located on the Contra Costa and Alameda County lines. The plant lifts water 244 feet from the intake channel to the California Aqueduct. The plant is about 98 feet wide and 469 feet long. The existing Delta Pumping Plant was designed for installation of eleven pumps. Seven of these pumps are presently in place and have an aggregate pumping capability of 6,300 cubic feet of water per second.

Future Pumping Units

A second application requests a Department of the Army Permit for the installation and operation of the four additional pumps in the Delta Pumping Plant. This second request will be addressed separately at a later date and will be evaluated in a supplement to the Environmental Impact Statement prepared for the existing pumping plant.

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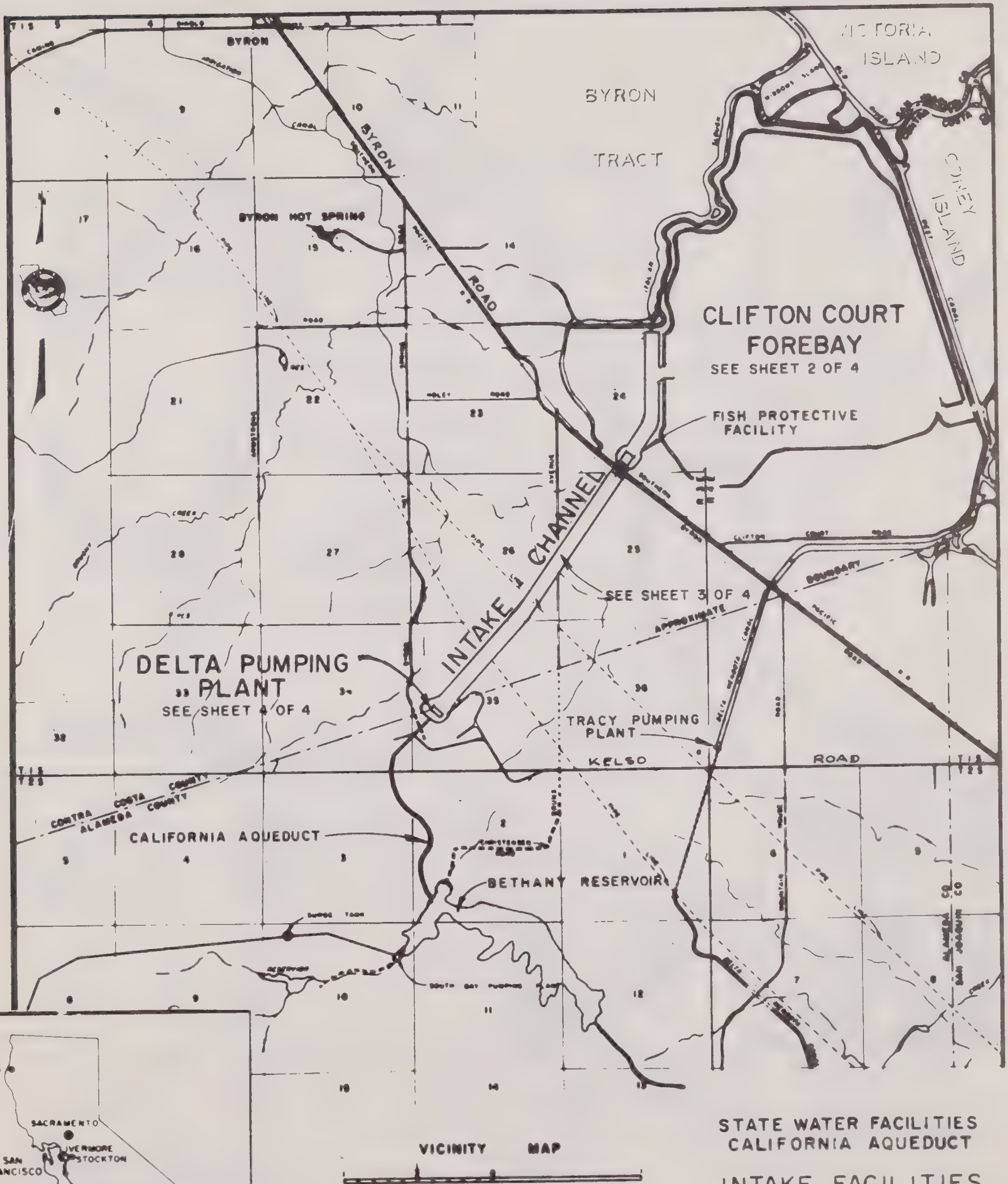


STATE WATER FACILITIES
CALIFORNIA AQUEDUCT

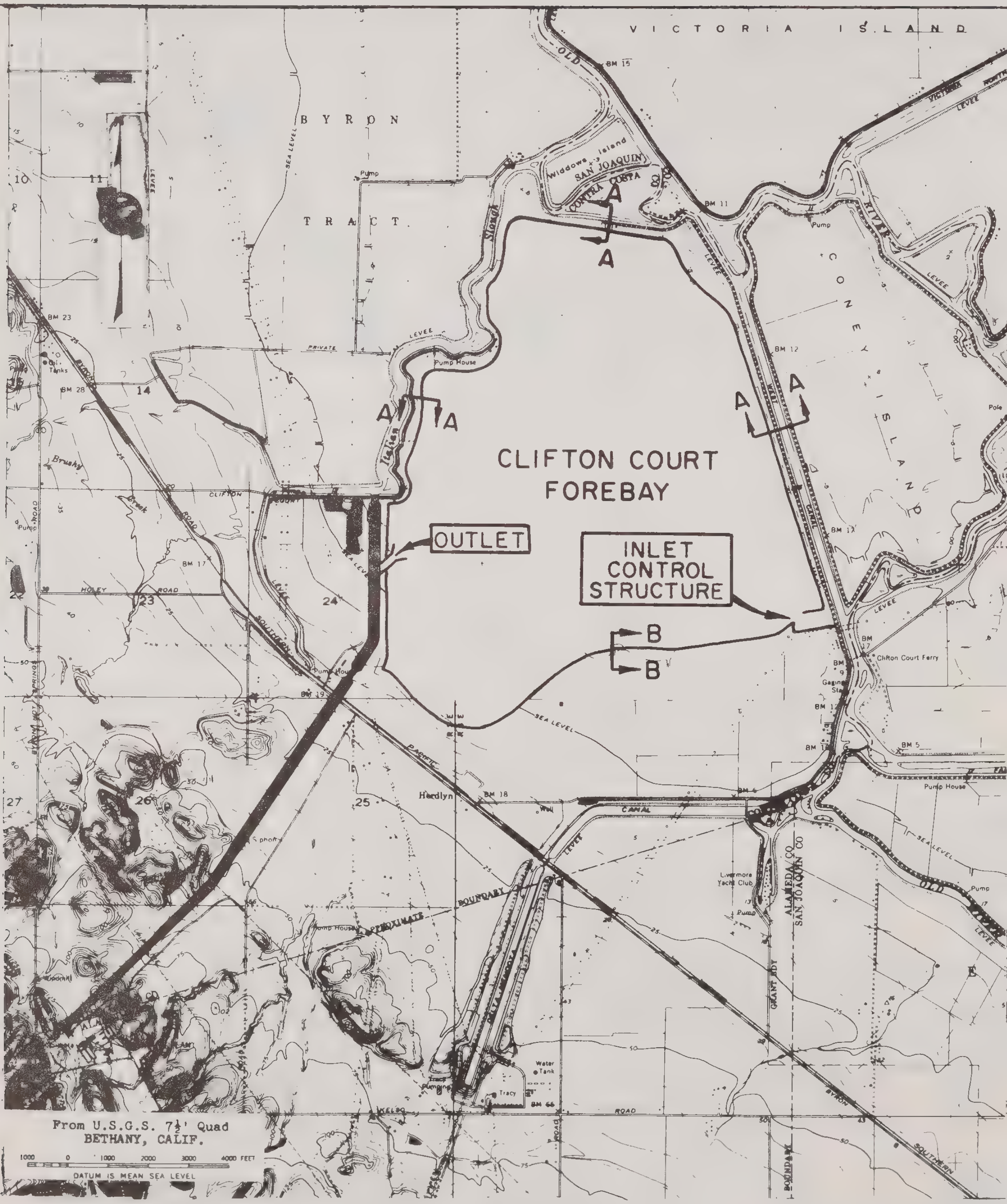
INTAKE FACILITIES

ALAMEDA AND CONTRA COSTA COUNTIES
CALIFORNIA

APPLICATION BY
STATE OF CALIFORNIA
DEPT. OF WATER RESOURCES

10/21/75 SHEET 1 OF 4

No. 5820



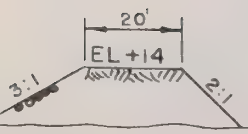
PLAN

STATE WATER FACILITIES
CALIFORNIA AQUEDUCT

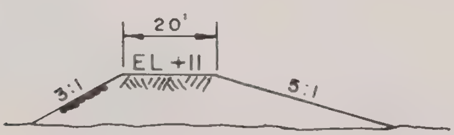
CLIFTON COURT FOREBAY

ALAMEDA AND CONTRA COSTA COUNTIES
CALIFORNIA

APPLICATION BY
STATE OF CALIFORNIA
DEPT. OF WATER RESOURCES



SECTION A-A



SECTION B-B

10/21/75 SHEET 2 OF 4

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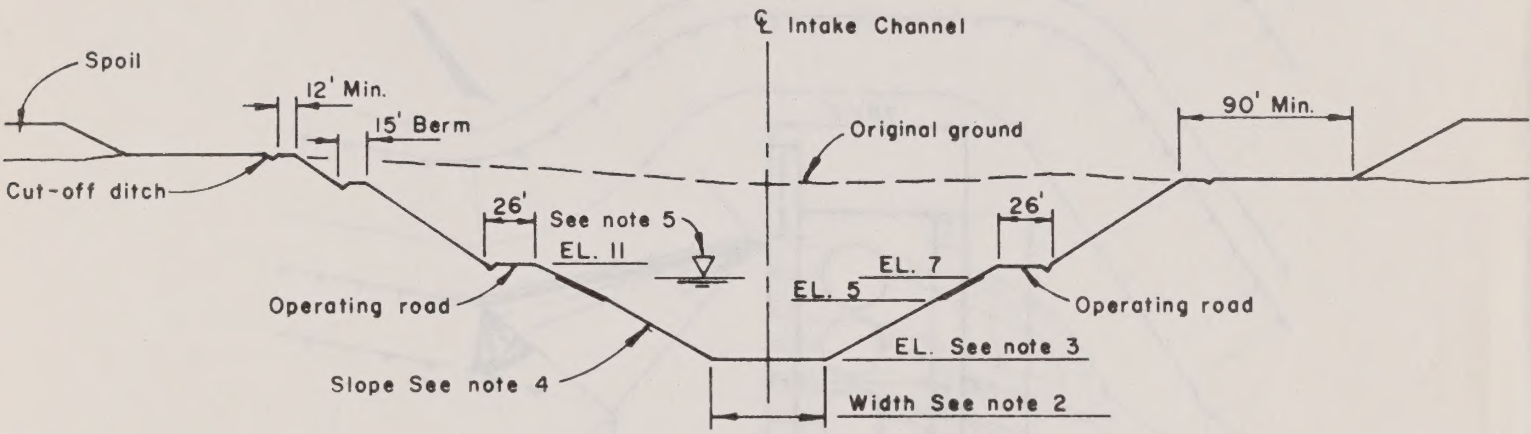


TYPICAL SECTION

Not to Scale

NOTES

1. All sections are symeterical about ℄
2. Bottom width varies from 60' to 80' in width
3. Invert elevation varies from −31 to −35
4. Slopes vary 1:1 or flatter above waterway prism
   Slopes vary 1.75:1 or flatter in waterway prism
5. Waterway prism depth varies from 42' to 46'
   Depth of flow varies from 38' to 42'

Elevations referred to Mean Sea Level Datum of 1929

STATE WATER FACILITIES
CALIFORNIA AQUEDUCT

INTAKE CHANNEL

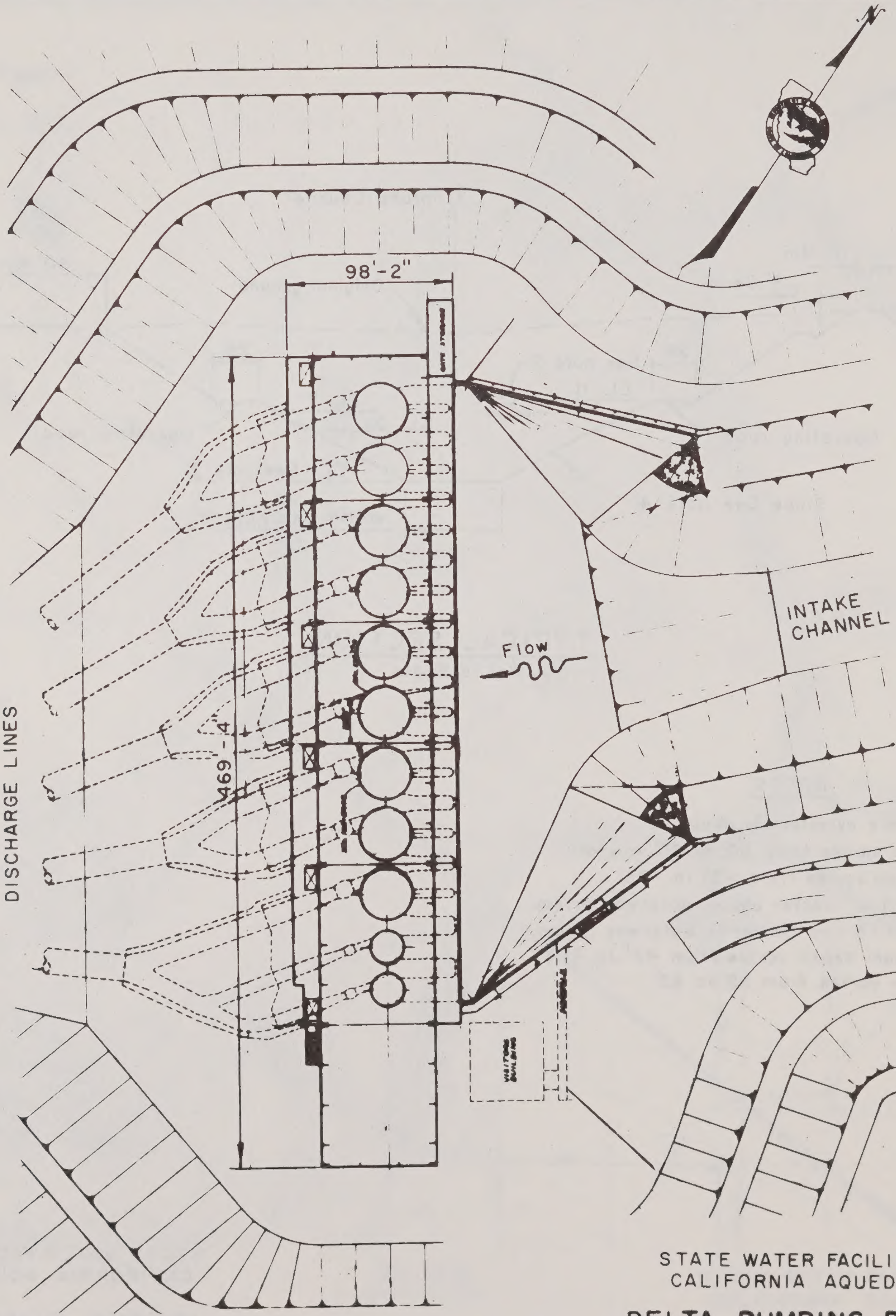
ALAMEDA AND CONTRA COSTA COUNTIES
CALIFORNIA

APPLICATION BY

STATE OF CALIFORNIA
DEPT. OF WATER RESOURCES

10/21/75 SHEET 3 OF 4

No. 5820



LEGEND

○ 1,067 CFS PUMPS

○ 350 CFS PUMPS

PLAN

20 0 20 100
SCALE OF FEET

STATE WATER FACILITIES
CALIFORNIA AQUEDUCT

DELTA PUMPING PLANT

ALAMEDA AND CONTRA COSTA COUNTIES
CALIFORNIA

APPLICATION BY

STATE OF CALIFORNIA
DEPT. OF WATER RESOURCES

10/21/75 SHEET 4 OF 4